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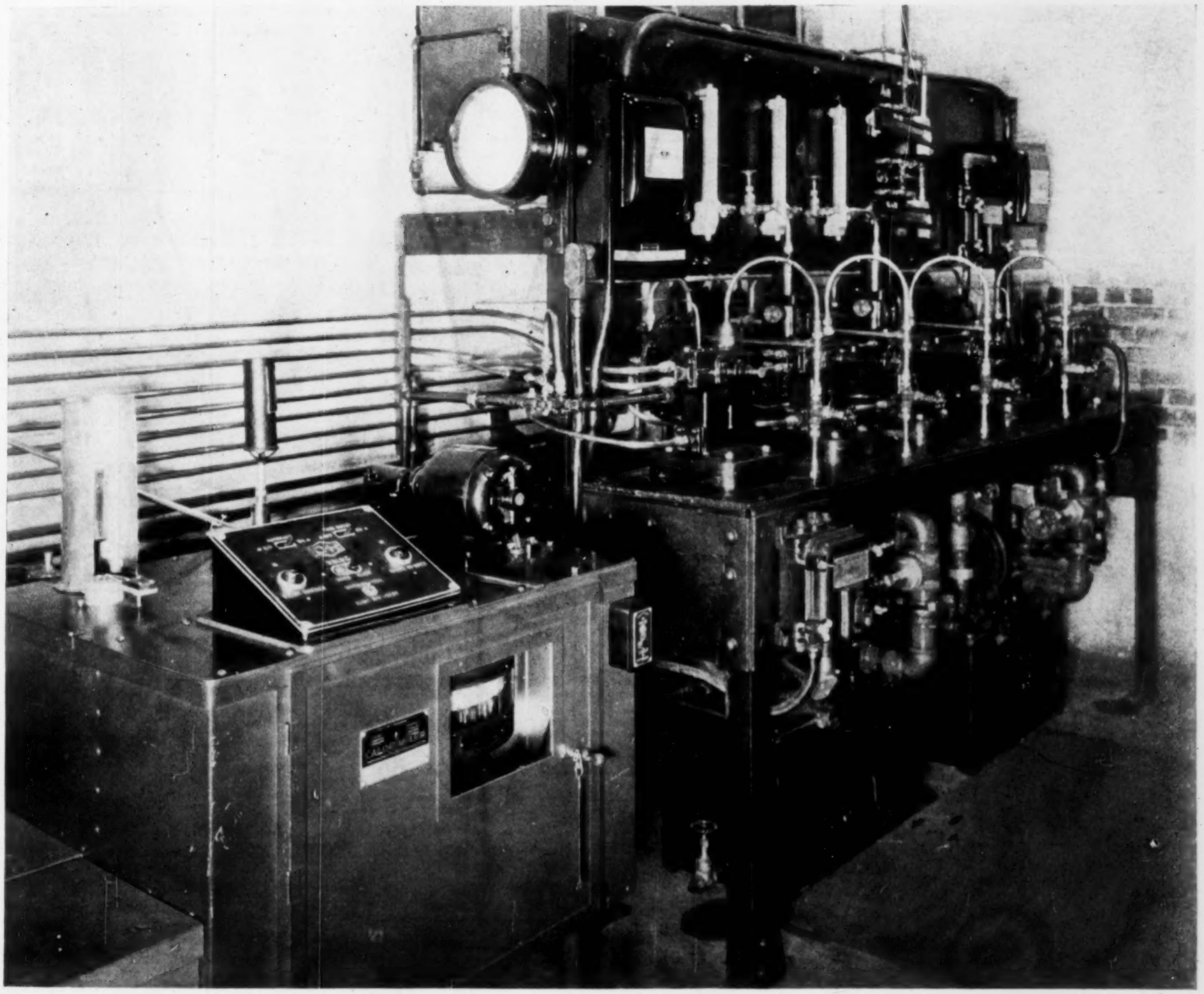

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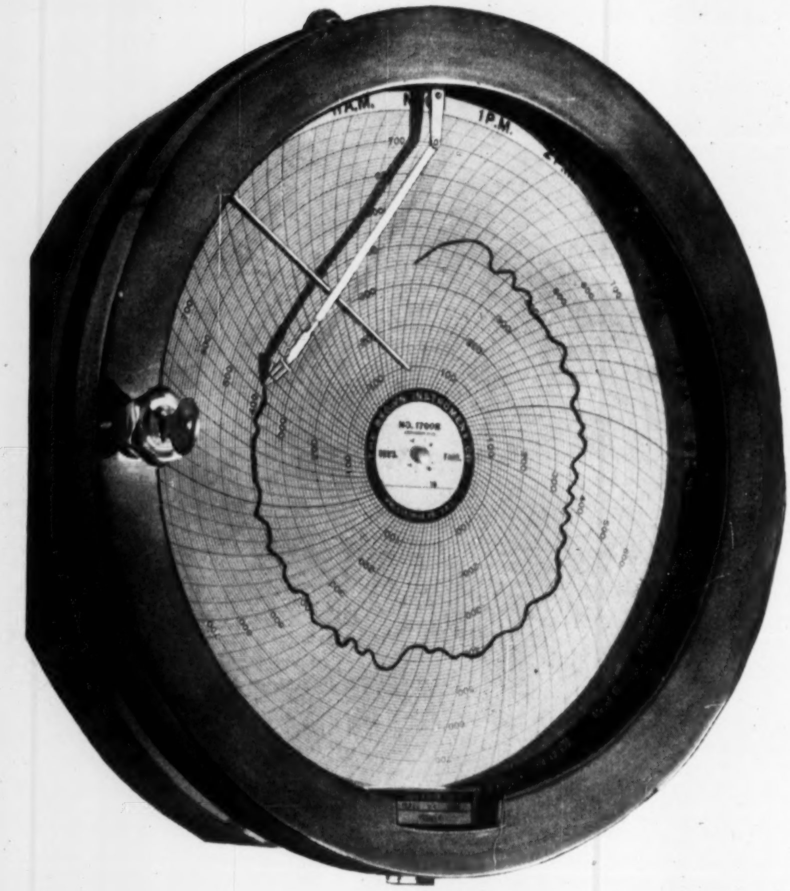
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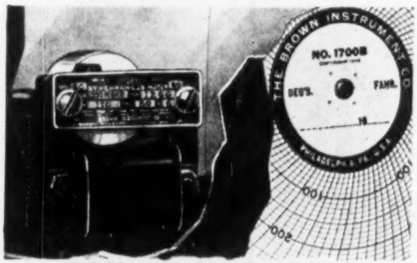
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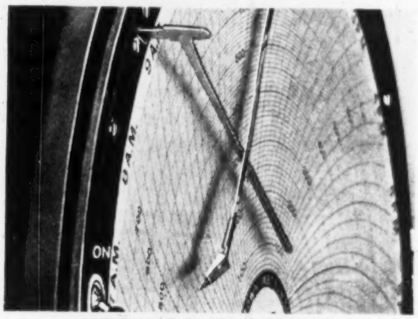

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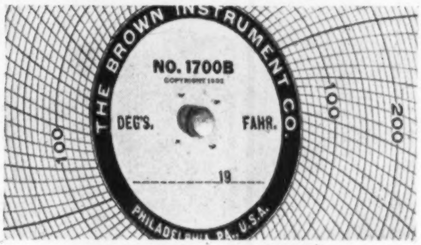
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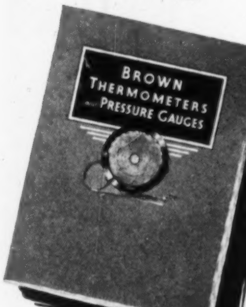
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INSTRUMENTS

THE MAGAZINE of MEASUREMENT and CONTROL

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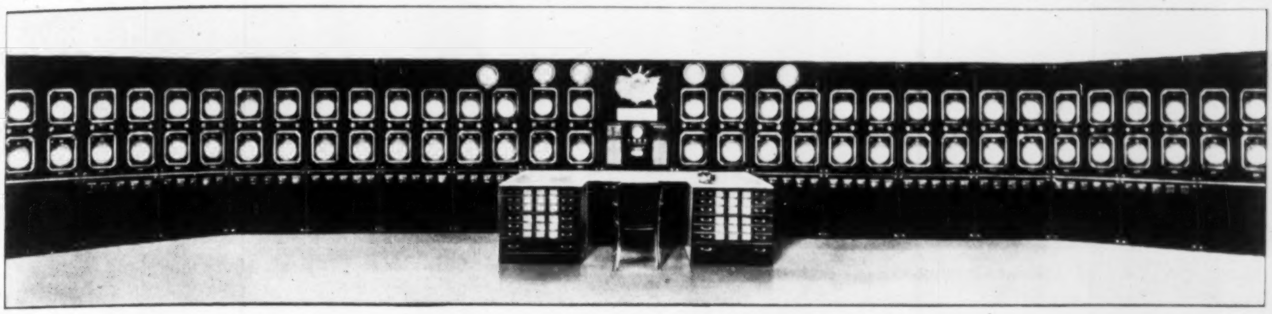
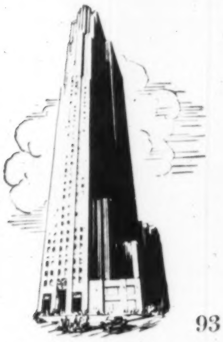
WHERE 64 SENTINELS OF N.B.C. WEATHER STAND GUARD—Focal point of this giant air conditioning system is a beautiful remote control room on the tenth floor of the R.C.A. Building. This panel of 64 Taylor Recording Regulators provides individual control of temperatures for N.B.C. broadcasting studios and offices.



THIS FAMOUS SYSTEM OF TEMPERATURE CONTROL

Designed and Installed at Radio City by Carrier and Taylor Engineers

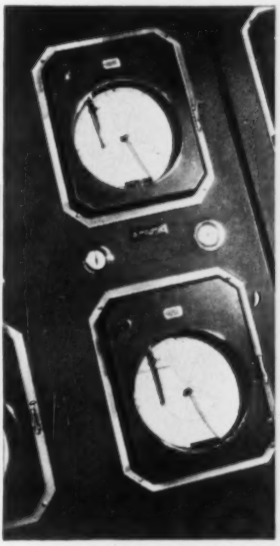
Provides N.B.C.'s Huge Weather-Making Plant with a Centralized Control That Regulates and Records Air Conditions for Each Separate Studio Within 1° ± ½



HIGHLIGHTS OF THE N.B.C. AIR CONDITIONING PLANT

...The most intricate air conditioning system ever built. Three years in the making. Cost approximately $1,000,000. Handles 23,000,000 cubic feet of scientifically conditioned air per hour. Provides complete air change every 8 minutes for N.B.C. studios and offices in Rockefeller Center's R.C.A. Building, the world's largest office building. Has a refrigerating capacity equal to 20,000 refrigerators.

The Carrier Engineering Corporation is contractor for the air conditioning plant. Working with them, Taylor Instrument Companies provided the temperature control system. Clyde R. Place are the consulting engineers.



In addition to the main control, 29 more Taylor Recording Regulators control and provide a continuous 24-hour record of the atmospheric conditions for all retail shops in the R.C.A. Building. As this close-up shows, they maintain the temperatures required within 1° ± ½.

93 Taylor Recording Regulators, 250 Taylor Industrial Thermometers, 104 Taylor Even-Action Valves, 37 Type-P Air-Operated Thermostats, 6 miles of tubing in individual lengths up to 375 feet. All coordinated by the engineers into a system of remote control so highly sensitive and accurate that it maintains any air condition desired in each of National Broadcasting Studios and retail shops in Rockefeller Center's new R. C. A. Building within 1° ± ½!

"Almost human," is the way A. Warren Canney, of Clyde R. Place, Consulting Engineers for this mammoth air conditioning system, describes it. It affords another example of how Taylor is serving industry today by working with other engineers to meet and solve difficult and exacting temperature control problems.

In every industry this same Taylor service is finding ways to new production economy and efficiency. For Taylor Service goes far beyond the installation and replacement of instruments. It brings to bear an experience of 80 years in meeting industry's temperature control needs.

This Taylor Service is available to any plant—large or small. To get it, call in a Taylor Representative. Let him talk with your engineer—study your requirements—make his recommendations. Address, Taylor Instrument Companies, Rochester, N. Y.

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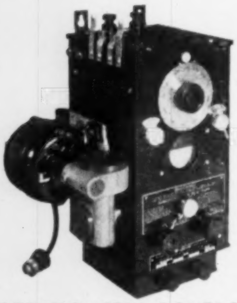
TEMPERATURE *and* PRESSURE INSTRUMENTS

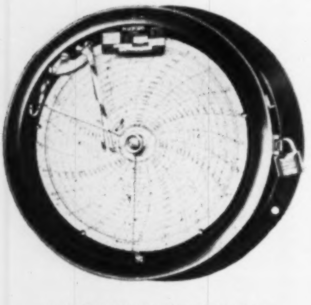
The name Taylor now identifies our complete line of products, including Tycos instruments.

"COMPLETE TEMPERATURE CONTROL"

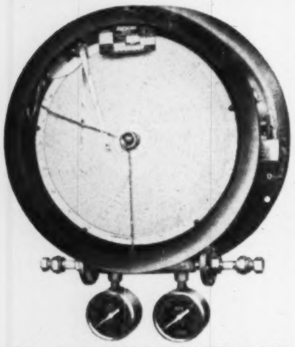
—by Foxboro



POTENTIOMETER CONTROL PYROMETER
Write for Bulletin 182



"ROTAX" ELECTRICAL CONTROLLER
Write for Bulletin 184



TEMPERATURE CONTROLLER OR "STABILOG"
Write for Bulletin 177

◆ Complete temperature control means accurate, dependable control of oil, gas, steam or electrical heat at any industrial temperature.

◆ It means adequate control for simple problems and correctly engineered control for problems involving complicated process lags.

◆ **There is no "Cure-All" for temperature control problems.** No one instrument—no matter how many gadgets and compensators it may contain—can give correct control on every problem.

◆ Solution of control problems requires a wide variety of instruments and engineering experience—Foxboro has both.

◆ Foxboro builds several types of control instruments—each suited for a particular purpose.

◆ Controllers can be furnished of either air or electrically operated types and with control action ranging from open and shut, throttling, and full-floating, to the stabilized control of the "Stabilog System." Our Engineers will be glad to analyze your problem and recommend the correct instrument for the job—there is no obligation—write today.

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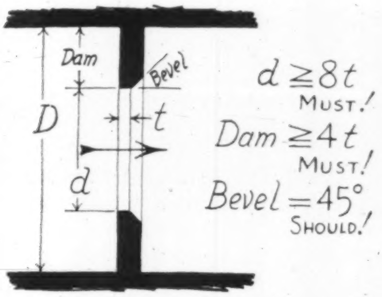
EDITORIAL COMMENT

In This Issue

◆ When is a "thin-plate orifice" not a thin-plate orifice? **Professor Beitler** tells you in the leading article, and gives limiting values of dimensions that must be observed in order that your coefficients won't misbehave. These values are indicated on our sketch herewith. What's more, Professor Beitler contributes two families of discharge coefficient curves that you can use with greater ease than previously published curves, both for vena contracta taps (Fig. 5) and for corner taps (Fig. 6).



◆ In most measurements by the null method the standard is of the same kind as the unknown. Examples, the equal-beam chemical balance and the "pure" Wheatstone bridge. The null method of a platform scale is not quite "direct" since the adjustable standard is not a weight but a length, but it is more convenient. Likewise in electricity the indirect null method frequently proves convenient. How *resistors* are used in a bridge circuit to measure an unknown *inductance* is told by **T. Slonczewski** in describing his development of the original Owen bridge into a practical instrument.

◆ Part Seven of the Manual of Instrumentation begins in this issue. This book will cover **Electrical Measurement and Control** from the industrial standpoint and is designed not only for E.E.'s, not only for technical graduates, but for all industrial users of electrical energy—thanks to the long experience of **Perry Borden,** an authority on the design and applications of electrical instruments.

The Front Cover

◆ Purchasing from nearby oil refineries large volumes of still gas which runs from 1200 to 1800 B.t.u./ft.^{3} and requiring for its East Chicago plant a gas-and-air mixture of constant heating value, the Youngstown Sheet & Tube Co. put the problem up to H. A. Brassert & Co., which solved it by installing an Askania control system operating from a Cutler-Hammer continuous calorimeter. The mixture varies between limits of 499 and 501 B.t.u./ft.^{3}—and another triumph is scored for Instrumentation.

Leisure Dividends of Instrumentation

BITTER controversies still rage over "technological unemployment." The persistence of this term in the vocabulary of non-technical politicians, writers and broadcasters betrays muddled thinking if not ignorance of the industrial basis of a decent civilization. Unfortunately, the clear-headed majority among our leaders has not yet squelched the pestiferous minority whose continued hysterical agitation against labor-saving devices impedes both recovery and reconstruction.

"Truth crushed to earth shall rise again." So with Instrumentation. You can halt some of it in all industries, you can halt all of it in some industries, but you can't halt all of it in all industries. *Instruments* will keep on fostering the march of automaticity as long as it endures. And to show we mean what we say, we shall use a portion of this very editorial to help widen the scope of Instrumentation by deliberately promoting its extension into the field of *inspection operations.*

To be sure, this has for years been one of our objects, but on December 13 we had the thrill of seeing an instrument (rather, a machine comprising five distinct instruments) which is used by the Ford Motor Company to inspect and classify engine wrist-pins.

Ground case-hardened pins enter one end of the machine at the rate of 38 a minute and are conveyed along its length past five stations spaced 7½" apart, halting at each station for a particular inspection (like "physical exam day" in the Army.) Station 1 tests automatically for surface smoothness by means of a Carboloy-tipped feeler swung in the field of a magnet in such manner that when roughness causes deflection beyond permissible extent, an amplified current trips a relay and the pin is ejected. Station 2 tests for scleroscopic hardness: if the hammer rebounds less than the proper extent between a light source and a photocell, a relay is tripped and the pin ejected. Station 3 tests for cylindricality by means of a U-shaped feeler which a taper of 0.0003" causes to deflect sufficiently to actuate a relay. In a somewhat similar manner Station 4 tests for concentricity by the three-point method. Station 5 measures diameter and its pointer controls a chute leading to one of five bins: oversize rejects, + 0.0001", ± 0.00005", − 0.0001", and undersize rejects.

We urge all industries now relying on manual and visual methods for such inspections to install automatic instruments similar to any or all of the five "stations" described above, thereby decreasing the sum total of human toil and increasing the per capita leisure of the American people.

Whatever device diminishes the sum total of drudgery—of repetitive labor tending to sharpen one faculty at the expense of all others—is a blessing. Don't use fewer such devices, as some politicians advocate; use more of them!

Don't let those politicians delude you into thinking that prices of material aids to civilization must be raised: The only way to increase the per capita utilization of motor cars, electrified and air-conditioned homes, radios, prepared foods, good shoes, fine clothes and so on is to make them much cheaper in relation to the per capita income; the only way to popularize symphony concerts and other cultural outlets is to increase the per capita leisure of workers.

Increasing the purchasing power of farmers and other favored groups, "soaking the rich," and other palliatives, cannot change the laws of economics: if the labor content of any material aid to civilization—say an electric waffle iron—is 1000 man hours, it will remain a luxury; if through labor saving devices its cost represents half of one minimum-wage day, millions will be sold, even to minimum wage earners. We repeat: don't use fewer instruments designed to cut down the labor content of your products; install *more* of them to expand your business and give work to more men.

We are all for the Roosevelt Reconstruction idea of equitably spreading both purchasing power and leisure, but *there must be more and more leisure to spread at the same time that more and more goods are produced and purchased.* We Americans can increase leisure by living like savages who don't travel, don't buy "gadgets," don't read, write or 'phone and therefore have no industries; but to increase both leisure and industrial activity we must adopt more and more leisure-producing instruments and control devices.—M. F. BEHAR

LETTERS TO THE EDITOR

The reader and the editor of a technical magazine may be unknown to each other, yet they are closely connected. The reader seeks to learn and benefit by the advances in his field of industry. For that reason he follows his chosen technical magazine. The editor aims to benefit his reader, so you and the editor both strive toward a common interest.

Much is gained by the editor in seeing things with the eyes of the reader. So co-operate in your common interest with him—WRITE TO THE EDITOR. Let him see in your letter the magazine as you see it. If there is something you do not like, or do not believe, or perhaps do not understand, write to the editor. Tell him all about it. In clearing up the matter he may uncover something important which is obvious when close at hand, but at the reader's distance is obscure. This may be of considerable help to other readers as well. To the editor your constructive criticism will be helpful for future guidance, and will be received with friendly appreciation.

Should you miss something in INSTRUMENTS that you feel ought to be there, the editor would like to hear from you about it. Perhaps other readers feel the same lack, then the editor will be pleased to have learned what is required of the magazine, and do his best to fill the requirement. If it is a matter in which you personally want a wider background, the editor feels at all times ready to call on all his facilities or connections and satisfy your inquiry to the fullest.

If you know anything new or more advanced about material in the magazine, write to the editor. Make your contribution on the matter to him. He will not only be thankful for your aid in widening his scope on the subject, but will gladly extend your contribution to his readers, giving due credit.

When you like anything in INSTRUMENTS, or are pleased with the way something is treated in it, write to the editor. The knowledge that he is running the magazine in the direction which fills the need as outlined by the readers will assure him of being on the right course—an assurance he always appreciates.

With this issue INSTRUMENTS begins its seventh year. This may excite in you ideas and opinions. Don't hoard them. Ideas, like dollars, produce results only when in circulation.

Instrumentation is Part of Columbia's M.E. Course

To the Editor:

In going through my files of *Instruments* I recently discovered an editorial of yours in the issue of April 1933, which I had overlooked in my first reading. In it you suggest that the engineering schools should pay more attention to the training of engineers in the theory and use of instruments. Consequently I am sure that you will be interested to know what is now being done in this department at Columbia and what our plans are for the future.

For many years we have maintained an instrument laboratory, and a course in instruments is the first laboratory course given to our Mechanical Engineering students. On account of the short time alloted to this subject they can do little more than study instrument principles but they get a good grounding in that.

We are shortly going to change our curriculum in order to meet the changes which have taken place in our profession during the past few years. This new curriculum will include a revised course in Instrument Laboratory, followed by a one-term, three-hour-per-week lecture course on Instruments and Controls. These two courses will be required for Mechanical Engineering students and open to others properly qualified. This first Instruments and Controls course will be largely qualitative. A more advanced course will also be offered which will deal with quantitative analysis of existing apparatus. It may be elected by regular students or students studying for advanced degrees.

If interest warrants a third course will be given on this subject for graduate students, which will consist mainly of problems of design of instruments and controls to meet specified conditions.

I have had charge of the instrument laboratory since it was first installed and shall give the Instrument and Control courses. I note in your editorial the offer of the coöperation of *Instruments* and I shall be very glad to avail myself of such coöperation. I shall highly value your ideas on this subject.

Columbia University — Harry L. Parr,
January 4, 1934 — *Prof. of Mech. Eng.*

Re-defining "Area Meters"

To the Editor:

I have read carefully the 12-page treatment of area meters in the December *Instruments* and consider it *very* good . . . There are only two criticisms, if you want them. First, it seems pretty ambitious to attempt a rigid definition of an area meter. My idea is that an area meter is a head meter which employs in place of a fixed orifice and a widely varying head, a variable orifice and a *more or less constant* head. I would admit the meter prover (Fig. 27 A.S.M.E.) and the vane meter, Fig. 33. If you take Fig. 33, turn it on its side so that gravity does not act, and put a spring on the vane instead to get away from the pendulum effect, you lose the resemblance to the hydrometric pendulum and you have a diagrammatic drawing of the Hodgson Kent small size air meter, undoubtedly an area meter. Fig. 33 is a variable area meter with a drop in pressure due to flow through a restricted area, the head being the difference between the impact pressure on the upstream side and the static pressure on the downstream side of the gate. Most area meters use the kinetic or impact pressure upstream, so does the Pitot tube and the impact nozzle. The Venturi tube in practice always uses the static pressures, however the Venturi could use impact pressure for upstream tap and would then correct for velocity of approach exactly as does Fig. 26, A.S.M.E. gate type area meter.

My second comment is on the velocity of approach factor. The usual formula corrects exactly for this *if* the flow is uniform (or exactly similar) in the section A_1 and section A_2 and if there is no contraction. It is practically correct for Venturi and for shaped flow nozzles. It is not correct theoretically for orifices where the actual area of the disk opening is used for A_2. However, in practice it is not possible to caliper the vena contracta and I presume the best thing to do is to follow the usual procedure and mop up whatever error there is in the formula by absorbing it in the coefficient. I consider this approximation the source of most variations in experimental coefficients of sharp-edge orifices, that is, in the turbulent flow range which includes practically all actual metering of water and lighter fluids. It seems to me that the use of impact head for the upstream pressure takes account of the velocity of approach factor to exactly the same extent as the use of the formula. Corrections for density (or for its components, pressure, temperature and specific gravity) are independent of the approach factor and are as necessary in the variable head meters as in the variable area meters. The same applies to the units used on the scale plate, whether gallons, cubic feet, under actual flow conditions, cubic feet under standard conditions, weight units, etc.

If I were to venture another definition of area meters, it might be: "Area meters are those in which a variable area of the flow stream in a closed conduit is the principal factor in determining the rate of flow. The head causing flow through this variable area is usually approximately constant but in some forms of area meters the head varies over a considerable range. The head may be the difference between two static pressures or between an impact pressure and a static pressure."

This lets in the meter prover and the vane meter. Of course it is a matter of choice what definition is selected but my idea would be to make a definition broad enough to let in all actual closed conduit meters using variable area of orifice, even though, as in the case of the vane meter, the variation in head might be almost as much of a factor as the variation in area. . . .

New Jersey Meter Co. — C. A. Dawley
Plainfield, N. J.
December 21, 1933

Spitzglass' Loss Felt Overseas

To the Editor:

It was with the deepest regret that I learned from your columns of the death of my friend, J. M. Spitzglass. He stayed once at my house here and we corresponded subsequently. I enjoyed his sincerity, kindliness and humor.

Eddington House — John L. Hodgson
nr. Leighton Buzzard, England
December 20, 1933

Profitable Leisure

To the Editor:

. . . I find that your magazine fills a need in the field of technical publications in that it is an impartial exponent in the important fields of mensuration and control. It is the type of magazine one likes to sit down to and browse through—thereby making leisure moments both entertaining and profitable.

I have received *Instruments* practically since its inception and note that it is constantly improving—particularly during the last year or so.

Best wishes for your continued success.

Hastings-on-Hudson, N. Y. — Charles F. Schmid
December 20, 1933

Determination of Discharge Coefficients of Sharp-edge Orifices in Pipes of from One Inch to Fourteen Inches in Diameter*

By S. R. BEITLER†

THE purpose of this article is to report results of tests to determine coefficients of discharge of sharp-edged orifices in pipes of various sizes, done under the auspices of The Ohio State University Engineering Experiment Station. The actual taking of data was in charge of Mr. T. C. Barnes for the larger-sized lines, and Mr. Cecil Van Gundy for the smaller lines. They were assisted by Mr. C. F. Bayer. The writer feels that much of the accuracy of the work is due to their extreme care in making the observations. The writer wishes to express his appreciation for the assistance and advice received from Mr. Howard Bean of the Bureau of Standards and Mr. R. E. Sprenkle of the Bailey Meter Co.; also to Dr. Edgar Buckingham of the Bureau of Standards who has made many valuable suggestions, and to Mr. J. E. Overbeck of the Columbia Engineering Corp., who has helped with the gathering of the data and also with their analysis.

FOREWORD
By T. H. KERR**

As Chairman of the Joint A. G. A.-A. S. M. E. Committee on Gas Measurements, I am personally familiar with the fact that the information contained in this article was developed by Professor Beitler at Ohio State University, using the same facilities as used in conducting the tests for our Committee, and I would recommend it to the careful consideration of anyone interested in the use of orifice meters.

Scope of Work. The work originally planned was to consist of the calibration of concentric orifices of relatively large diameter ratio in pipes of 3", 6", 10", and 14" I.D. Coefficients were to be determined for all types of pressure taps most used in commercial metering, namely, Flange Taps, Throat Taps, Vena Contracta Taps, Pipe Taps, and Corner Taps. When completed, data had been taken for the sizes mentioned above and for 1", 1½", and 2" pipes with a much wider range of diameter ratios. The orifices tested were as follows:

One set of orifice plates with orifice diameters varying from ⅛" to 1⅝" for use in 1" and 1½" and 2" lines. These gave diameter ratios of approximately from 0.24 to 0.77 in the 1" line, of from 0.15 to 0.76 in the 1½" line, and of from 0.[illegible] to 0.80 in the 2" line.

One set of three orifice plates for the 2" lines with diameter ratios of from 0.12 to 0.25 for check orifices.

One set of orifice plates for the 3" and 6" lines with orifice diameters of from 0.25" to 4.8" giving diameter ratios of from 0.08 to 0.78 in the 3" line, and of from 0.04 to 0.79 in the 6" line.

One set of orifice plates for the 10" line with orifice diameters of from 2" to 8.2", having diameter ratios of from 0.19 to 0.81.

One ½" thick orifice plate for the 10" line, with an orifice 2" in diameter.

One set of orifice plates for the 14" line with orifice diameters of from 3" to 12", giving diameter ratios of from 0.21 to 0.85.

One 0.80" thick orifice plate for the 14" line, with a 3" orifice diameter.

Several of these plates were calibrated with different orifice edge thickness and bevelings, to determine the effect of edge thickness on coefficient. All orifices were calibrated using water as the calibrating medium, tests being made with differential heads varying from about 4" of water to about 50 ft. of water.

In all, there were 1008 test runs on 65 different orifice plates in six different sizes of line.

DESCRIPTION OF APPARATUS

Orifice Plates. The orifice plates were constructed of Monel metal or stainless steel, of sufficient thickness to prevent appreciable deflection even under a high pressure drop: ⅛" for lines 10" and under, and ¼" for the 14" line. The plates were made with "ears" or tabs for identification marks and the method of manufacture was approximately the same for all sizes of orifices. The orifice was first bored, care being taken to keep the edge square. The burr turned up by the machining process was removed, either by scraping or honing. After the orifice was finished, the edge was examined under a 100 power microscope for visual imperfections. The plates were not given any special treatment but were machined as are all commercial plates in the shops of the three manufacturers who contributed them: The Ohio Fuel Gas Co., The Bailey Meter Co. and The Metric Metal Works of the American Meter Co. 90% of the plates were without unusual evidence of any roughness or rounding of edge. About 10% showed some rounding, not enough to cause a very large difference in coefficient, but enough to be noticeable in the results. All the orifices in the 2" lines and smaller, as finally tested, had the downstream edges of the orifices beveled at a 45° angle to a thickness of less than ⅛ of the orifice diameter. As a part of the work a study was made of the effect of this bevel on the coefficient.

Orifice Section. The orifice plates were clamped between special sections of pipe with arrangements for taking the pressure at 2½ pipe diameters, 1 pipe diameter, 1 inch, and at the plane

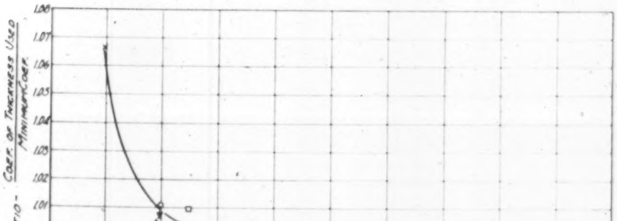


Fig. 1. Effect of diameter-edge thickness ratio on orifice coefficients.

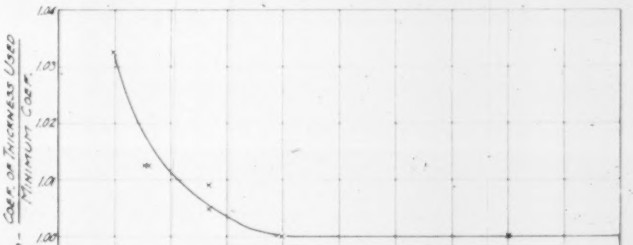


Fig. 2. Effect of dam height-edge thickness ratio on orifice coefficients.

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*Substance of paper bearing same title and by same author, contributed to the Special Research Committee on Fluid Meters of the American Society of Mechanical Engineers, for presentation at its session during the annual meeting of the society, Dec. 4-8, 1933.

†Assistant Professor of Mechanical Engineering, The Ohio State University.

**Vice-Pres., Ohio Fuel Gas Co., Columbus, O.

of the orifice upstream; and (downstream) at the plane of the orifice, at 0.4, 0.5, 0.6, 0.7, 0.8 and 8.0 pipe diameters, and 1″ downstream from the orifice plate. Orifice plate hoider flanges assured that orifices and upstream and downstream pipe sections were perfectly concentric in every set-up. "Corner taps," at the faces of the orifice flanges, were made according to the dimensions given by R. Witte, in his 1930 paper (V.d.I. Reglen fur die Durchflussmessungen mit genormten Dusen und Blenden) which has been adopted as standard in Germany, using an annular chamber communicating with the pipe by a slit not over 0.03 pipe diameters wide. Other pressure connections were made by drilling ¼″ diameter holes through the pipe and flanges. Care was taken to make these holes smooth and straight, and their edges inside of the pipe were slightly rounded.

Upstream connections were made in a straight line parallel to the axis of the pipe. Downstream connections on pipes 3″ and under were spaced in a spiral around the pipe so that there would be sufficient metal between holes; on larger lines the downstream taps were in a straight line. This allowed taking all pressures along the pipe simultaneously.

Gaskets of compressed asbestos were used to keep the correct distance between orifice plate and pipe ends.

Orifice Test Line. Test lines in general were set up with as much straight pipe upstream from the orifice as possible. The distances upstream were as follows:

Line	Pipe Diameters Upstream
1″	270
1½″	170
2″	140
3″	92 and 124
6″	30 and 84
10″	33
15″	30

For the 3″ and 6″ orifices the lines with the shorter upstream pipes were used only for small ratio orifices. All of the straight sections were preceded by straightening vanes to eliminate swirls.

Vents, drains, and thermometer wells were installed as needed so as not to interfere with flow to the orifices.

Water for calibration purposes was supplied by pumps and at various times various combinations of pumps were used. The pumps available were as follows:

1— 2″ Screw pump	Capacity	50 G.P.M.
1— 3″ Centrifugal pump	Capacity	280 G.P.M.
1— 3″ Centrifugal pump	Capacity	500 G.P.M.
1— 6″ Centrifugal pump	Capacity	2,000 G.P.M.
1— 6″ Duplex pump	Capacity	1,500 G.P.M.
1—20″ Centrifugal pump	Capacity	10,000 G.P.M.

Sufficient line and enough valves were placed between the pumps and the orifices to damp out any pulsation effect.

Quantity Measurements. Quantity of water flowing was measured either by weight or by volume.

For the weight runs, scales with a capacity of 1500 lbs. and having a least count of ½ lb. on the beam were used. Tanks with a capacity of about 1200 lbs. and fitted with 2½″ quick opening valves were mounted on the scales. Two sets of tanks and scales were used and a deflector pipe was used to shift the flow from one tank to another.

The bays used for the volumetric runs were concrete tanks with approximate capacities as follows: Bay No. 11, 1000 cu. ft., Bays No. 11, No. 12, and No. 1, 3000 cu. ft., and Bay No. 2, 1500 cu. ft. The bays are connected by 2″ pipes to ¾″ gage glasses in a central measuring pit in the center of the laboratory so that the water level in each bay can be read on a scale placed behind the gage glass. Thermometers were placed in these gage glasses at about four-foot intervals to get the temperature of the water in the glass. The volume of water present in the bay for any gage reading was determined by calibration and was read from a calibration chart.

Manometers. Three different types of manometers were used for measuring the differential heads: (A) For extremely small heads ($<$ 12″ of water) a differential hook gage reading to 0.001″ was used. (B) For heads from 1 ft. to 10 ft. of water, a multiple inverted water manometer was used. This was a special manometer with large section manometer tubes and designed to operate with a maximum static pressure of 25 lbs./in.². (C) The differentials of $>$ 10 ft. were measured by means of ordinary mercury manometers mounted under the pipe so as to be self-venting.

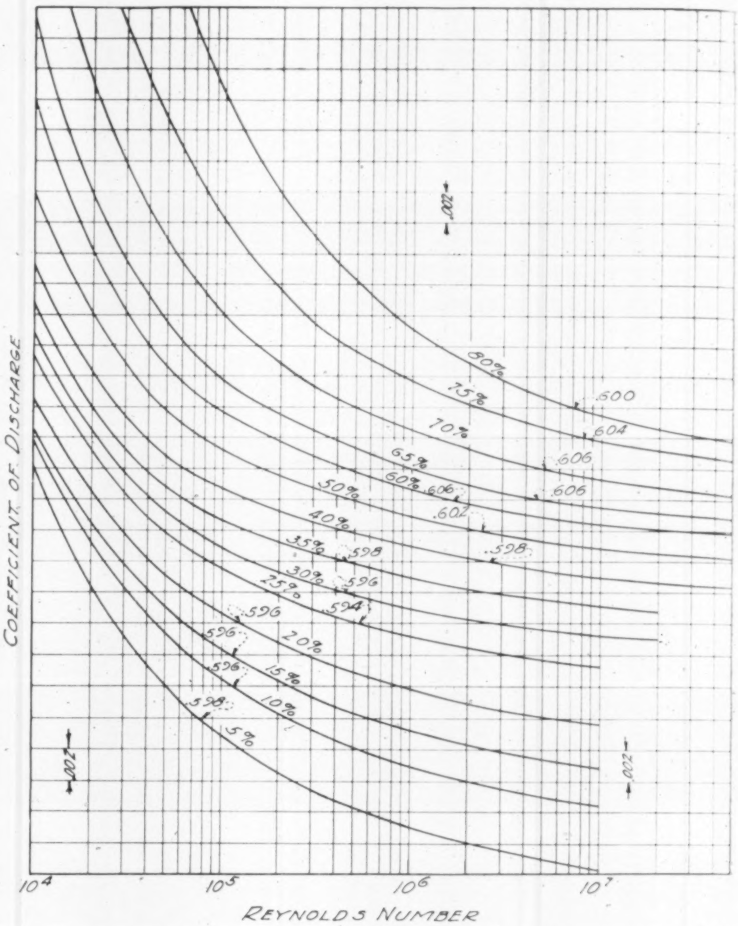

Fig. 3. Variation of coefficient of discharge with Reynolds number for different diameter ratios (Sharp-edge orifices, vena contracta taps).

METHOD OF TAKING DATA

For *weight runs* the method of taking data was as follows: With the orifice bolted in place between the flanges, the pumps were started and flow was established through the line. The static pressure was brought up to 10 lbs./in.² and all air vented out of the test line. The flow was then adjusted to give the desired pressure drop across the orifice. The water was allowed to flow into and through one of the weighing tanks back into the suction bay. While the flow was being adjusted, the valve in the second weigh tank was closed and the tare weight of the tank found. After all of the conditions were satisfactory and at a definite time, the deflector pipe was snapped over to discharge into the other tank and the two tanks were alternately filled, weighed, emptied and weighed in the usual manner for some definite time, usually fifteen minutes. Readings of the heads and temperatures were taken at desired intervals throughout the run. The heads were read simultaneously by two observers while a third operated the weighing tanks.

In making *displacement tests,* the water was allowed to run into the suction bay while the flow was being adjusted. The water level in the measuring bay was then read and at a definite time the deflector pipe was snapped over to discharge into the measuring bay. Readings of head and temperatures were made as in the weight runs, until the test was ended by deflecting the water back into the suction bay at the time decided upon by ending the run. After a sufficient length of time had elapsed for surging to cease in the measuring bay, the final reading was taken. All readings of bay elevation were checked by two observers.

Differential heads were held constant during the runs by controlling the pump discharge valves. During the weight runs there generally was no change in head. During the displacement

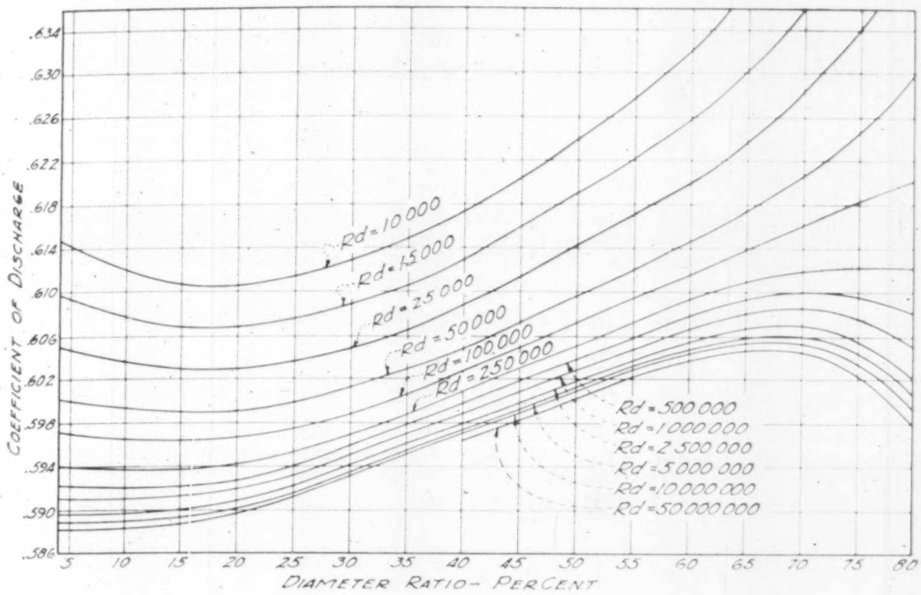

Fig. 4. Variation of coefficient of discharge with diameter ratio for different Reynolds numbers (Sharp-edge orifices, vena contracta taps).

runs there was a tendency for flow to drop as water was pumped from the suction bays, giving an increased suction lift on the pumps. This was compensated for by gradually opening up the pump discharge valves.

The *length* of the run was controlled by one of several factors. For the weight runs at least 2000 lbs. of water was collected or the run was made 15 minutes long. For bay runs in order to secure sufficient accuracy the minimum level increase in the water level was limited to 4 ft. If the water level increased more than 4 ft. in 30 minutes, the test was limited to this length of time. Otherwise the test ended when the measuring bay was completely filled. Observations were taken so that the maximum time between readings was 2 minutes and the minimum number of head readings was 16, except for very short runs. For some of the 14" tests where the time was extremely short (2 minutes or less) the number of head readings was less, due to lack of time. For determining the time of the longer runs an ordinary watch with second hand was used, while the shorter runs were timed with three stop watches operated by three separate observers. The corrected readings of these watches were averaged.

DISCUSSION OF RESULTS

Method of Analysis. At the time of the preparation of this article the results for the vena contracta taps and corner taps are the only ones thoroughly analyzed by the writer, and so this discussion will be limited to those taps. The amount of data accumulated being too large to permit its publication in this article, only the final curves of the analysis of results will be presented.*

The method of analysis for both types of taps was as follows: First the coefficient of discharge without velocity of approach was calculated for each test run made. (On each orifice there were normally runs at approximately 0.4, 0.8, 2, 4, 6 and 9 ft. differential heads for the vena contracta taps and at all except the 0.4 ft. for the corner taps.) These coefficients were then plotted against differential head to determine if there was any apparent variation in experimental data. If any points were out of line these test runs were checked. Then the average of the coefficients for the five or six runs were plotted against diameter ratio for each pipe size to determine if there was any orifice whose coefficient did not line up with the rest of the orifices in that size line. If an orifice was found which did not line up with the rest, it was carefully inspected, retested and a check orifice plate was made and tested.

After all of the data were taken, the Reynolds numbers R_d were calculated for all runs, using the orifice diameter and the velocity at the plane of the orifice.† Coefficient-Reynolds number curves were then plotted for diameter ratios of 12.2, 15, 20, 25, 30, 35, 40, 50, 60, 70, 75, and 80% (Fig. 3). If the orifice tested was not of the exact ratio to be plotted, the values of Reynolds number and coefficient were corrected to that ratio by calculating the change in the Reynolds number due to change in ratio, and by reading the amount of change in coefficient from the coefficient-diameter ratio curves mentioned in the preceding paragraph.

Curves of coefficient against diameter ratio for different Reynolds numbers were then plotted (Fig. 4) and the coefficient-Reynolds number curves were changed so that the coefficient-diameter ratio curves for any value of Reynolds number would be smooth.

The final diameter ratio-coefficient curves (Fig. 5) were then drawn. To get the points for these curves the values of Reynolds number for air at 30" of mercury absolute pressure, 60° F. and 50" of water differential and for air at 600 lbs./in.² absolute pressure, 60° F. and 100" of water differential, were

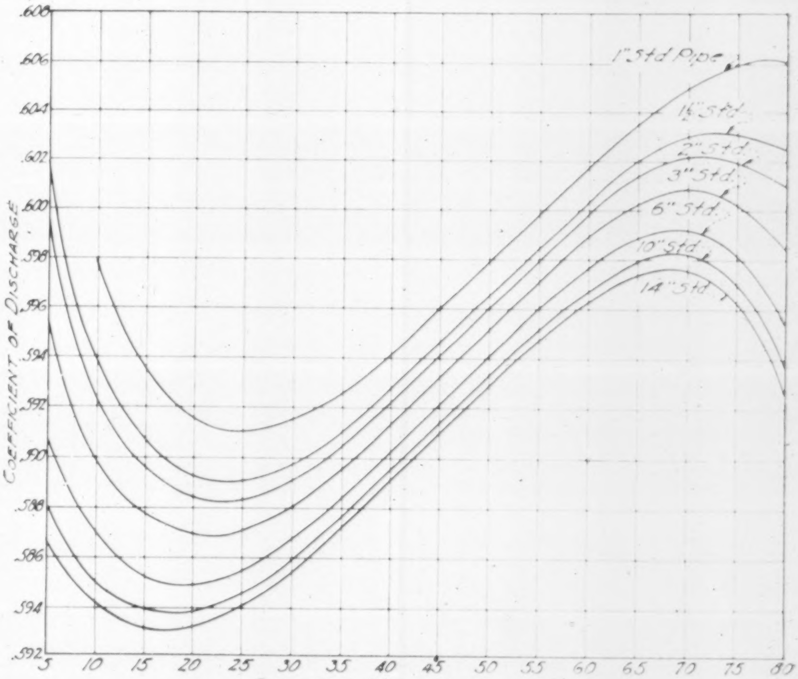

Fig. 5. Coefficient of discharge-diameter ratio curves for air at 60° F., 30" mercury abs. pressure and 50" water differential corrected for compressibility (Vena contracta taps).

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*It is the intention of the Engineering Experiment Station of The Ohio State University to publish a bulletin in the near future, giving the data and results for these tests in their entirety, so that the results can be analyzed by any one interested. This bulletin will give the results on all types of taps and some other studies which were made in relation to this work.

†The origin and use of this ratio for the studying of orifice flows is discussed thoroughly in the Report of the A.S.M.E. Fluid Meter Research Committee, Part 1, Appendix C.

calculated for the line sizes tested, and for various ratios. In calculating these values, a coefficient of 0.6 was assumed. The values of the coefficients at these Reynolds numbers taken from the coefficient-Reynolds number curve for that ratio were then plotted.

Effect of Edge Thickness. A preliminary inspection showed that some of the thick orifices gave coefficient values much higher than those with a thin edge and so a study was made of the effect of edge thickness.

The curves in Figs. 1 and 2 were plotted to show the effect of the relation of edge thickness to orifice diameter and to the height of the orifice (dam height) inside the pipe, i.e., $(D\text{-}d)/2$. The first curve was plotted for orifices of 50% diameter ratio or less where the same plate was tested with several edge thicknesses. The average values of the coefficients for similar runs were used to determine the points. This shows that if the orifice diameter is equal to or greater than eight times the edge thickness the coefficient is constant, but if it is less than eight times, the coefficient increases very rapidly for a decrease in this ratio.

Fig. 2 shows the effect of edge thickness on large ratio orifices, where the diameter is greater than eight times the edge thickness. This is plotted against $(D\text{-}d)/2$ or dam height of the orifice and shows that this must be taken into account in determining the coefficient of an orifice. It appears from this curve that dam height should always be greater than four times the thickness of the edge of the plate.

It appears to be evident from this study of edge thickness that the orifice diameter must be at least eight times the edge thickness and that the dam height must be four times the thickness of the edge; also that the downstream edge of the orifice should be beveled at an angle of 45 deg. to give coefficients which are not subjected to effect of downstream orifice edge. The bevel did not seem to have such a great effect on the larger sized orifices, but the edge effect was very apparent.

In general, it appears to the writer that it would be well to standardize on the thickness of plate and thickness of edge to be used in all cases, considering the necessary physical strength required and the other limitations. Since a plate of ⅛" thickness seems to have sufficient strength to resist buckling for all except the largest lines and is probably the most used commercial thickness, this would appear to be the best thickness to use. If the edge were beveled to 1/32" all orifices above ¼" would fulfill the requirement as to ratio of orifice diameter to edge and all orifices of 80% ratio and under in lines 1½" or more in diameter, would fulfill the requirements for the dam height ratio. Therefore, a ⅛" plate beveled to 1/32" would fulfill all the requirements as to a standard orifice plate except for largest lines. Thinner plates would probably do for the lines 3" and under, but a thin plate is much more difficult to machine without distortion and therefore is not as satisfactory as a plate at least ⅛" thick.

Vena Contracta Taps. The following analysis applies only to orifices which have sharp edges and which have edge thickness-diameter ratio and edge thickness-dam height ratios equal to or greater than the limiting values given in the above paragraphs.

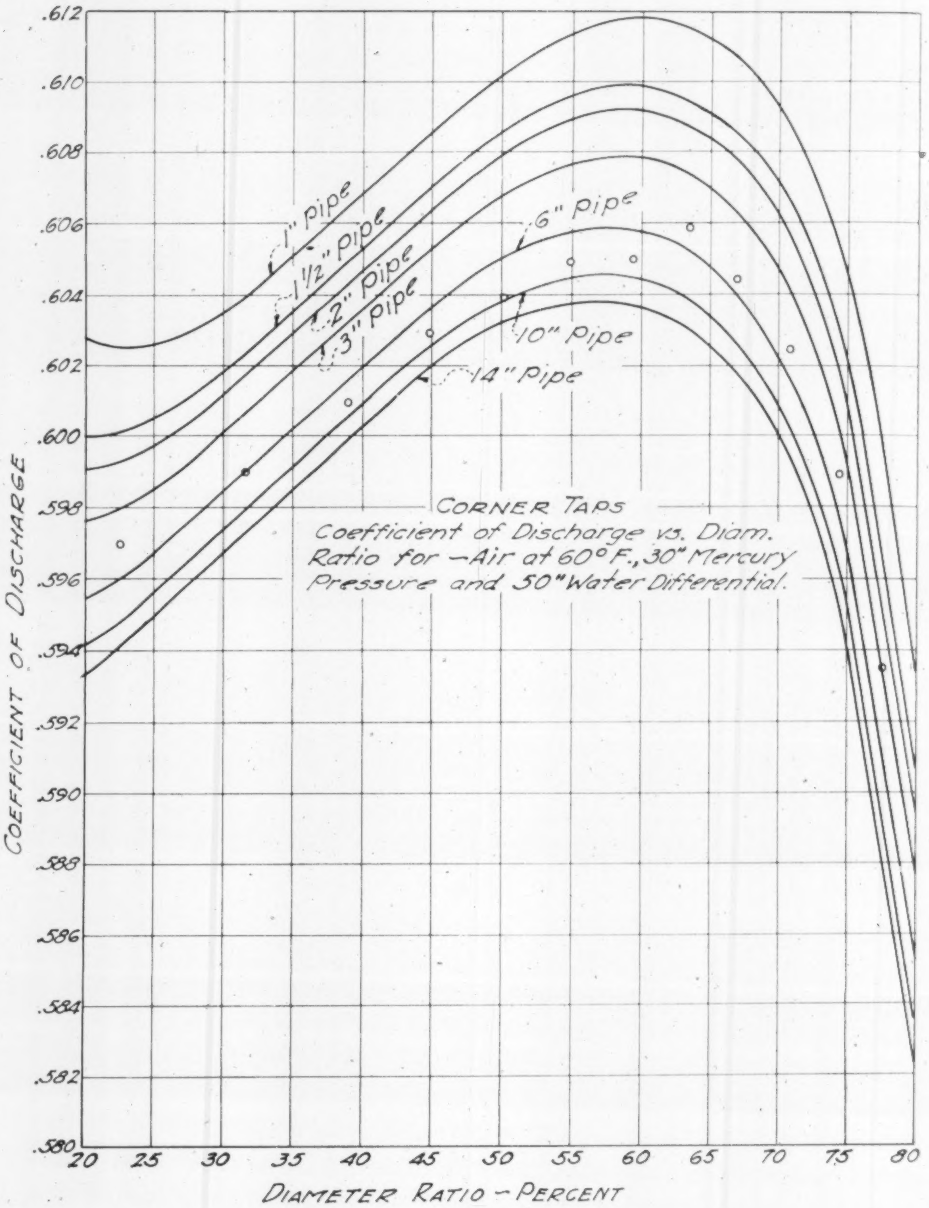

Fig. 6

Fig. 3 shows the variation of coefficient with Reynolds number for all of the orifices tested using vena contracta taps. These taps were studied first because they appeared to give the most logical results and because there were more data available for them than for the other taps. In making this study the results of tests on orifices in 3" lines made for the Bailey Meter Co. and reported upon in 1931 were included (See A.S.M.E. R.P. 54-1932).

The variation of the points from the curves was in most cases less than 0.5%, except for the large ratio orifices. It was more difficult to reproduce results and orifices for the larger ratios than it was for the smaller ones. However, it appears from these curves that for any diameter ratio the coefficient varies with Reynolds number and is independent of pipe size. In the series tested there was one 1" line, one 1½" line, one 2" line, two 3" lines, two 6" lines, one 10" line, and one 14" line with quite dissimilar roughness, and yet this apparently had no regular effect on the coefficients. A close study of any of the curves shows that for some ratios the coefficients for smaller lines are higher than those for the larger lines, while for other ratios this is reversed and there seems to be no regularity in the order in which they fall. This seems to prove that there is more error introduced from inaccurate test data and from orifice plate edges than there is from assuming that the law of similarity is exactly true.

The curves as plotted differ from those previously published in one very important detail. That is, instead of becoming flat at a value of Reynolds number of about 100,000, these curves

(Continued on Page 8)

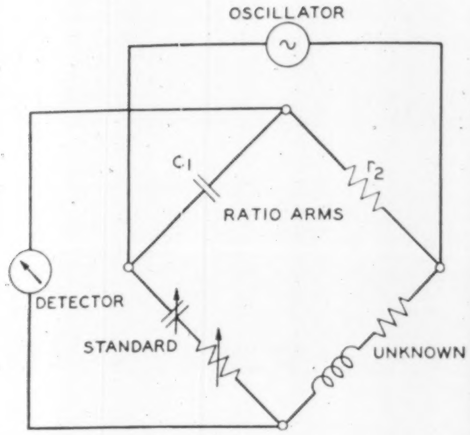

Fig. 1. In the Owen bridge one of the ratio arms is a resistance and the other a capacitance, while the standard consists of a variable capacitance and a variable resistance.

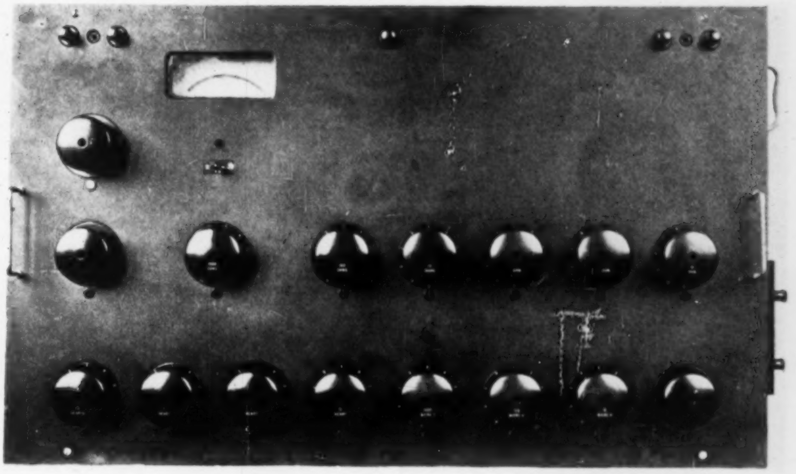

Fig. 2. The new bridge incorporates its standard and ratio arms in a single compact unit.

A Bridge for Measuring Inductance

By T. SLONCZEWSKI*

IT has been found upon investigation in Bell Telephone Laboratories that by employing a bridge network due to Owen†, which contains no inductance standard, indirect measurements of inductance can be made that are particularly well adapted to commercial uses. The Owen bridge, shown schematically in Fig. 1, has a resistance in one arm and a capacitance in the other. The unknown is connected in the branch opposite the capacitance ratio arm, while a variable resistance and a variable capacitance are employed as standards in the arm opposite the resistance ratio arm. The advantage of this type of circuit is that to balance the inductance of the unknown, the operator need only adjust the resistance standard, and to balance the resistance component of the unknown, only the capacitance standard is adjusted. This is possible because when the bridge is in balance, the unknown inductance is equal to the product of the capacitance and resistance of the ratio arms and the resistance of standard, while the unknown resistance is equal to the product of the capacitance and resistance of the ratio arms divided by the capacitance of the standard.

Since the values of the resistance and capacitance of the ratio arms are fixed, the only variable in the measurement of an inductance is the standard resistance. Instead of engraving the value of this resistance in ohms on the dials, therefore, the product of this resistance by that of the two ratio arms is engraved so that the inductance of the unknown may be read directly from the dials in henrys. In a similar manner the dials of the standard capacitances are engraved to give the resistance of the unknown directly.

The advantage of the Owen type bridge is that a resistance takes the place of an inductance as the variable standard. A resistance is less bulky than an inductance standard, and small size, in general, means small stray capacitances. The effective resistance of a resistance coil, moreover, is much less affected by stray capacitances than is the inductance of an inductance coil, and as a result it has been found possible to construct a six dial standard with its resistance practically independent of frequency.

In the purity of the standard the Owen bridge has the advantage that the reactance of resistance coils can be made either positive or negative by proper design so that by suitable adjustment the error in effective resistance of the standard is reduced to a negligible value. Moreover, resistance coils may be adjusted to nearly their nominal values, are independent of current value, and are stable with time and temperature. As a result, costly calibrations are dispensed with entirely, and the bridge maintenance is inexpensive.

These advantages of the Owen bridge have been known for a long time, of course, but because of the asymmetry of the bridge, it has heretofore been impossible to maintain the proper phase relation between the two ratio arms over a wide range of frequency.

One ratio arm is a resistor and the other a condenser, and for a proper balance the impedance vectors of the two arms should be at right angles to each other. The phase angle of a condenser suitable for use in the bridge arm remains practically constant with frequency. The phase angle of the resistance, however, increases with frequency due to the effect of the distributed capacitance, and as a result the difference in phase between the two arms does not remain 90° for all frequencies. To make it do so would require that a compensating coil with a positive reactance which would remain constant with frequency be connected in the resistance arm.

It is only the result of two developments in Bell Telephone Laboratories—a coil with a reactance that does remain constant with frequency, and a proper shielding scheme—that has made the Owen bridge of practical importance for this work. As shown in Fig. 2 the new bridge, exclusive of oscillator and detector, has only two rows of dials, and an indicating ammeter for measuring the current through the unknown. As already noted, one of the sets of dials measures the resistance component of the unknown and the other the inductance component.

Although the new bridge has a larger inductance range than the one it replaces, it is much smaller and easier to manipulate and to maintain. It is well suited to work involving precision measurement of inductance and effective resistance. By the Western Electric Co. it is employed for measuring the inductance of coils manufactured for use in audio frequency filters.

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*Telephone Apparatus Division, Bell Telephone Laboratories, Inc.

†*Proceedings Physical Society*, London, Oct. 1, 1914.

The **American Society for Testing Materials** has moved its headquarters to the Atlantic Bldg., 260 So. Broad St. (cor. Spruce), Philadelphia.

R. E. Murphy of R. E. Murphy Co., Grant Bldg., Pittsburgh, has been appointed sales manager of I-T-E Circuit Breaker Co. and will make his headquarters at the company's main office in Philadelphia.

Herbert Thacker Herr, vice president of the Westinghouse Electric and Manufacturing Co., died recently at his home in Philadelphia, at the age of 57, after an illness of about five months. Widely known in engineering circles, Mr. Herr was inventor of improvements in air brakes, turbines, oil and gas engines, and remote control for steam turbines.

Arthur A. Brown, assistant to vice president, Westinghouse Electric & Manufacturing Co., died suddenly in his home at Mt. Vernon, New York, at the age of 60. Before joining that company in 1904 he had been connected with the H. B. Smith Co., Westfield, Mass., as apprentice; the Bethlehem Steel Co. as machinist, then Assistant Superintendent for the H. B. Smith Co., General Superintendent of the Richmond Co. of Norwich, Conn., and General Manager of the Rarig Engineering Co. of Columbus, Ohio.

Discharge Coefficients of Sharp-edge Orifices

(Continued from Page 6)

are still showing considerable slope. This slope is large for small and large ratio orifices and not so great for the ratios between, reaching a minimum at about 50% d/D ratio.

Fig. 4 shows the variation of coefficient with diameter ratio for different values of Reynolds number. These curves are used in plotting coefficient-Reynolds number curves for any diameter ratio, and so the coefficient of discharge for any ratio orifice at any value of R_d between 10,000 and 50,000,000 can be determined.

Fig. 5 was plotted from points taken from the original coefficient-Reynolds number curves, using the coefficient at the Reynolds number for air at 30" of mercury absolute pressure, 60° F. and 50" water differential. The general shape of these curves is similar to those previously published for vena contracta taps. (See A.S.M.E. Fluid Meters Committee Report, third edition, page 38.) The values, however, are quite different for the smaller lines and for the large ratios in all lines.

That there is any difference with line size is due to the fact that the coefficient-Reynolds number curves slope over the whole range and so give lower coefficient values for the larger pipes with larger values of Reynolds number. This fact confirms the findings of earlier investigators.

It is the opinion of the writer that a curve of this sort, together with correction factors for Reynolds number changes, is more practical for general use than are the original Reynolds number curves, because it makes it easier to interpolate for odd sizes than these other curves do. If the curves for atmospheric air are used, the corrections will be both plus and minus, that is, the multipliers will be greater than one for lower Reynolds numbers and less than one for high Reynolds numbers. The maximum amount of the correction for atmospheric air conditions would be about 0.8% (plus or minus as the case may be) for a 75% ratio orifice.

Corner Taps. While corner taps are not used to any great extent in this country, they are standard in Germany and have been suggested as an international standard. There is available also a large amount of test data for these taps, notably that of R. Witte, so that the results can be compared with the results of others.

Fig. 6 shows the coefficient-diameter ratio curves for the same air conditions as used for the vena contracta curves. Plotted in these curves are the values given by Witte, as representing the average coefficients for lines of from 50 to 310 mm. (1.97" to 12.2" dia.). These values of Witte practically average the values for atmospheric air for lines from 2" to 14". The maximum differential to which Witte worked was about 500 mm. of mercury minus water (20.6 ft. water) and as mercury manometers were used for all heads the tendency would be to get slightly different coefficients than when using water manometers for the lower heads and with differential heads as high as 52 ft. of water. Considering the difference in methods, the writer feels that the agreement between the values is good. The major difference in results is again due to the fact that Witte says that the coefficient-Reynolds curve is flat above a certain Reynolds number, which, as stated previously, was not found to be true in these tests.

General Conclusions. It is the opinion of the writer that for general use a curve of the type of Fig. 5 for vena contracta taps or of Fig. 6 for corner taps should be used in specifying orifices. After the coefficient is chosen from the curve the proper corrections should be applied for difference in Reynolds number and compressibility. Nothing has been said here about the correction for compressibility, as that is another, though closely related, problem. The correction for change in Reynolds number can be found by comparison to the coefficient-Reynolds number curve of ratio nearest to the desired ratio, or by determining some general correction to apply, depending upon pressure and differential for a gas or vapor and upon differential for a liquid. It would probably be better to give tables of these corrections for different fluids and conditions than to ask the ordinary orifice meter user to calculate the Reynolds number for each orifice which he wished to use.

If the orifice is properly constructed and installed, the coefficient of any orifice will be within ½% of the values taken from the curves for the same condition, and probably will be much closer than ½% of this value. This will be true if the orifice is constructed according to the recommendations made under the discussion of effect of edge thickness. This accuracy is as great or greater than that of any other metering element which can be reproduced as easily as can an orifice, and proves the desirability of the orifice meter for all accurate metering purposes.

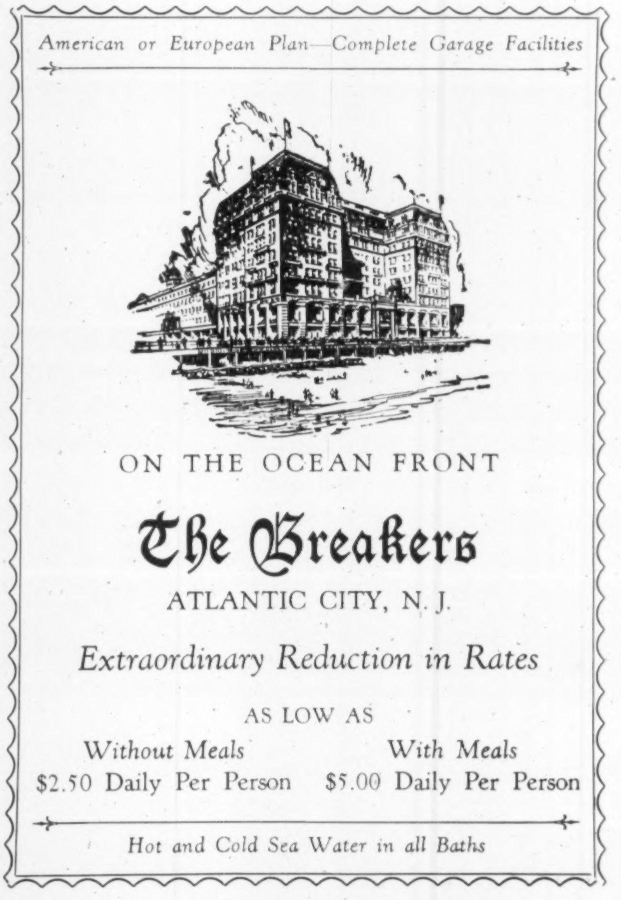
Care should be taken, however, in the choice of size, and if possible the diameter ratio should be kept between 20% and 75%. Orifices with higher and lower ratios were found to be less easily reproduced and more subject to external influences. For smaller ratio orifices the allowable tolerance must be increased with a decrease in ratio to about ±1% at 10% ratio and even higher than this for smaller ratios. This is especially true in small pipes as it is much more difficult to make similar orifices for diameters of less than ½".

Curves are given for pipes as small as one inch; however, it is the opinion of the writer that for lines of less than 2" diameter the orifices should be individually calibrated in the line for accurate metering.

While values given are for vena contracta and corner taps only, the curves for flange and throat taps are quite similar except for high ratio orifices and for the fact that the absolute values are somewhat different. Pipe taps show about the same differences for variation of Reynolds number and about the same consistency for diameter ratios up to about 50%, but larger ratios apparently were very much affected by pipe roughness and so were not at all consistent. For this reason, the coefficients for pipe taps for large ratios are difficult to predict.

Northern Equipment Co., Erie, Pa., announces the appointment of The C. J. Gaskell Co., Box 162, Memphis, Tenn., as representatives for Copes feed water regulators, differential valves, pump governors and allied equipment.

The Bristol Company, Waterbury, Conn., announces that in order to serve the Canadian market still better and to expand and consolidate its present Canadian service laboratory of 12 years standing so as to include sales, service and manufacturing, a separate company, The Bristol Company of Canada, Ltd. has been incorporated. Factory and general headquarters will be located at 64 Princess St., Toronto, Ont., where Bristol recording, indicating and control instruments will be made. J. S. Mayberry, graduate engineer of Toronto University, and for 10 years with the parent company, has been appointed manager.



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General Considerations of Electrical Measurement and Control*

By PERRY A. BORDEN†
and M. F. BEHAR**

1. Brief Survey of the Field

The uses of electrical energy in industry may be classified as follows:

(1) *Processing conditions* as in electric furnaces, electrolytic processes, electric welding, and the precipitation of finely divided solids from gases

(2) *Motive power*: The driving of conveyors, elevators, rolling mills, machine tools and numerous specialized forms of textile, rubber, paper, tobacco, chemical, wood-working, ceramics, plastics and food-products machinery; to which service is related—

(3) *Measurement of non-electrical magnitudes* such as temperature, flow, pressure, speed, chemical conditions, etc.

(4) *Manual and automatic control of conditions*, including the remote control of valves, dampers, etc., the automatic regulation of temperatures, pressures and chemical conditions.

(5) *Illumination*: The general and special lighting of the plant.

(6) *Communication and signaling*; including bells, pilot lights, telephones, remote indicators, etc.

(7) *Safety*: from the simplest cut-out to the most elaborate interlock circuits.

Problems of electrical measurement, however, confront us not only in the above-mentioned aspects of the utilization of electrical energy but to an even greater degree in the power house and on the circuits through which the electric current is made available to industry.

Electrical instruments thus have manifold duties to perform. In some instances they appear only as indicators, giving the user an idea of the present value of the magnitude with which he is dealing, in other cases as recorders, providing a permanent record of energy consumption or of the performance of some unit of the plant. Electrical instruments are often essential to the successful operation of mechanical units; and to those responsible for the supply of electric power to industry and commerce, electrical measuring devices become the cash registers of the system and establish the revenues of the great electrical utilities. It therefore follows that not only is there a variety of electrical magnitudes to be determined, but that the system of measurement and the required precision must vary greatly under differing conditions.

The measurement of electrical magnitudes is a clearly defined subject and, while closely related to, need not be confused with, the use of electrical means for the measurement of non-electrical magnitudes, such as speed, etc. Since this Manual as a whole, however, deals with the subject of control as well as measurement, there immediately arises the problem of just what we shall define as electrical control in this volume. The term may be, and is, applied to such subjects as the control of production machines, locomotives, ocean liners or any device depending upon electric motors for propulsion. It may be applied with equal correctness to musical instruments and to heavy artillery, to dial telephones and to traveling cranes. Electrical control forms the basic elements of almost every robot and helps to swell the pages of many popular publications. As electrical control in its conventional sense is a subject much too broad for this Part of the Manual, a distinct effort will be made to conform to the principles of other Parts of the work in dealing only with the actual *automatic con-*

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[*] First chapter (XXIX) of Part Seven (Handbook of Industrial Electrical Measurements and Control) of Béhar's *Manual of Instrumentation*. See editorial announcement of this series on page A7 of November 1933 *Instruments*. A complete chapter of this new handbook will be published in each issue of *Instruments* throughout 1934 and 1935. Each chapter is to be subjected to a final revision, and then set in type, shortly before its appearance in this serial form, in order to assure that the subject matter is thoroughly up-to-date. This new book is not published serially in any other periodical. Entire contents copyright. To be issued in book form on or about Jan. 1, 1936.

[†] Member A.I.E.E.

[**] Editor, *Instruments*

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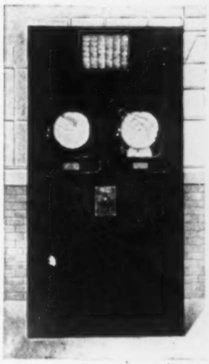
—CONTROLS—

COMBUSTION control to maintain steam pressure and combustion economy.



Control Panel

SYSTEMS to regulate pump speed, reheat temperature, desuperheat and other factors.

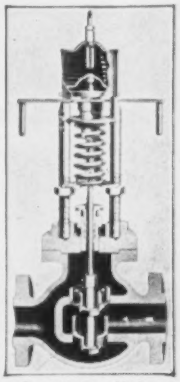
CONTROLLERS for rate of flow, pressure, temperature and other factors.

—REGULATORS—

FEED WATER regulators for feed water to steam boilers.

PRESSURE regulators for heating and process services.

DRAFT regulators to maintain the desired draft in furnaces, kilns and small steam boilers.



Regulating Valve

Complete information on any of the above Bailey products will be gladly furnished upon request.

G 1

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INSTRUMENTS BOOK SHELF

Gas Analysis by Measurement of Thermal Conductivity. By H. A. DAYNES. London, 1933, Cambridge University Press (New York, The Macmillan Co.). Cloth, 5½x8¾ inches; viii + 357 pages. Price, $4.25.

Yes, a full-size treatise entirely devoted to the thermal conductivity method of gas analysis—and not one of its 130,000-odd words represents padding or pedantry. Dr. Daynes, with the assistance of the U. S. Bureau of Standards and of English and American instrument companies, has "at one stroke" done for this field of instrumentation what it took Féry, Wien, Planck, Burgess, Forsythe and so many others down to Ribaud last year to do for optical pyrometry. We draw this parallel advisedly, instead of citing resistance thermometry, because the platinum coil has always enjoyed confidence whereas an indirect physical method of chemical analysis required an able advocate even after it had been developed so fully that it had begun to be used for the control of processes. Henceforth it may reasonably be expected that conductivity cells will be used not only in laboratories but in plants, with as much confidence as are optical pyrometers.

Although it is entitled "Historical Introduction," Chapter I describes the various possible methods and discusses them in such a way that the reader not only becomes acquainted with the principal sources of error but gains the impression that these have been discovered, are well known and can be compensated for in practice—an impression which is strengthened in Chapter II where the relations of composition, conductivity and instrument readings are formulated and conductivity data given for numerous pure gases and gas mixtures. Chapters III, IV, V and VI describe every practical type of cell and of circuit and discusses them at length with a profusion of formulas and circuit diagrams.

Then comes the feature which alone makes this book stand high above the general literature of measurement: four chapters, totaling 56 pages, on the time lag of the conductivity cell, on sensitivity, on all sources of variance and zero creep, and on methods of calibration, the treatment of these matters being thoroughly modern—almost like a series of *Instruments* articles and almost suitable for process men. The reviewer must say "almost" because Dr. Daynes seems to have written *these* chapters for laboratory Ph.D's rather than for industrial users, to judge from his own remark at the end of Chapter IX on "Stability of Zero":—

" . . . It will be seen that there are many factors affecting stability of zero and that *it is necessary for each worker to experiment* with his own conditions . . . Where the conditions of *experiment* permit, some zero errors may be automatically eliminated and the sensitivity doubled at the same time by the device of interchanging the gases in the two cells of the meter and taking the difference of the readings under steady conditions before and after the change . . ." (Italics are reviewer's.)

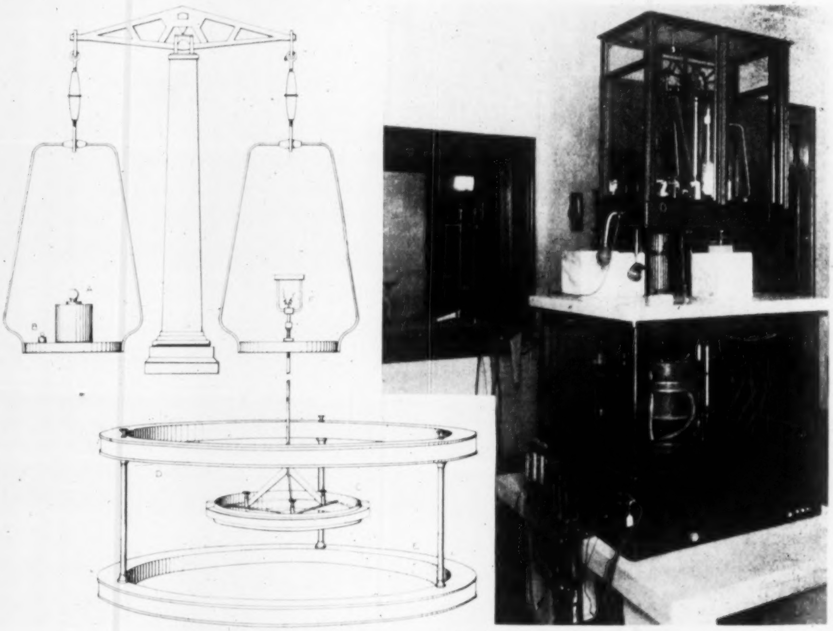
Chapters XI and XII, which discuss accessory apparatus and divide methods of analysis into five broad classes, do not call for mathematical and advanced scientific training on the part of the reader and are evidently intended for process men as well as laboratory workers, but the author here seems to forget his industrial readers' desire for automatic control—which he dismisses with a brief note. The next five chapters deal with industrial applications such as combustion, airships, production of industrial gases, etc., and discuss critically but fairly the numerous commercially available devices made by four English, four American, and two German firms, including four automatic controllers of which only one is

(Continued on Page 12)

trol of electrical magnitudes, rather than trespass in the fields of accompanyin volumes by attempting to treat the control of a variety of magnitudes and devices through electrical agencies.

2. Characteristics of Electrical Instruments

Electrical instruments differ in a number of essential features from devic commonly employed in many other engineering measurements. While with a relatively small expenditure of energy the electric current can be made t produce great mechanical forces, this is generally at the sacrifice of precisio and if exactness of relationship between the electrical and the directly measurable magnitudes is to be obtained, it usually is essential that relatively smal actuating forces be made to suffice, with a consequent smallness and lightne in the parts of the instruments. Thus, while the mechanical construction of a electrical instrument is generally simple, the mechanism is comparatively del cate, requiring careful handling, and subject to adjustment and repair only b skilled electrical instrumenticians.



THE RAYLEIGH CURRENT BALANCE AT THE NATIONAL BUREAU OF STANDARDS, WASHINGTON, TYPIFIES THE HIGHEST PRECISION GRADE OF ELECTRICAL INSTRUMENTS.

Diagram Showing Principle of Current Balance

A—Weight to counterbalance suspended coil
B—Weight to balance magnetic force on suspended coil
C—Suspended coil
D—Upper fixed coil
E—Lower fixed coil
F—Stirrup for holding leads to suspended coil

An electric current flowing through coils C, D and E is measured by weights balancing the electromagnetic force exerted on C.

The Current Balance as Actually Used

The two fixed coils can be seen in the lower case. The moving coil suspended from the balance arm is enclosed. Weighings are made by an observer outside the room through windows at left—at night after street cars stop running, and only on nights when earth's magnetic field is fairly constant. "Weighings must not have an error as great as one in ten million," writes Dr. E. C. Crittenden.

Whereas in many industrial measuring instruments the actuating and restoring forces are derived from a single element of the mechanism (such as a Bourdon tube), in electrical instruments the two forces necessary to a definite measurement are almost universally derived from *separate sources*. This will be gon into further in the April instalment.

Electrical instruments have in them elements subject to the effects of temperature changes; for not only must the expansion of mechanical parts and th varying characteristics of springs with temperature variations be allowed fo but the change in resistance of electrical circuits due to the same condition may have very important effects on the measured value of the magnitudes. Fortunately, it generally is possible to provide nearly complete compensation fo temperature effects.

A further characteristic of electrical measuring devices lies in the fact th they may be both productive of, and sensitive to, stray electrostatic and electromagnetic fields. This makes it important that in the use of electrical instrument due precautions be taken as to the electrical and magnetic conditions existin in the immediate neighborhood of the measuring equipment, and the proximit of adjacent instruments.

3. Classes and Types of Electrical Instruments

There are several ways in which electrical instruments may be classified, and each classification has its use. One system is according to the degree of care and expertness which they require; and this is in almost direct proportion to the precision of the results which may be expected from them. Thus, we might divide them into such groups as

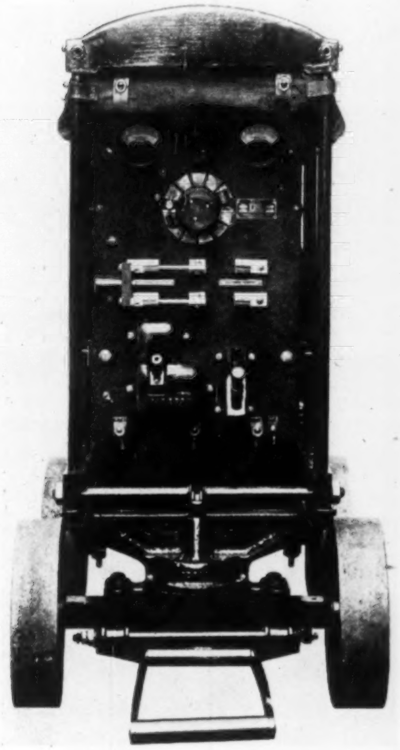
(*a*) the delicate scientific instruments,

(*b*) the electrical laboratory instruments,

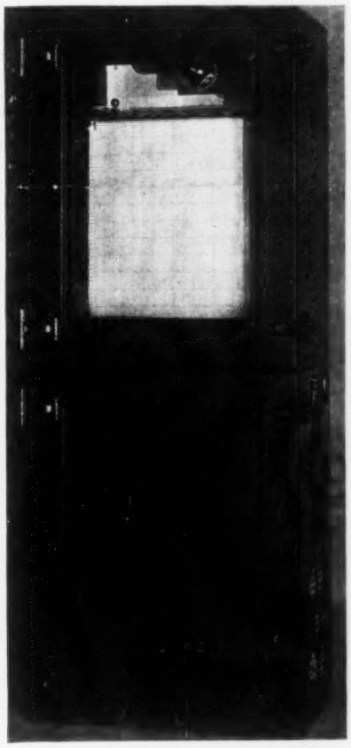
(*c*) the portable testing instruments,

(*d*) the switchboard instruments which require some care and occasional checking of accuracy, and finally

(*e*) the commercial instruments which are supposed to serve uninterruptedly for years without maintenance.



TYPICAL INDUSTRIAL ELECTRICAL INSTRUMENTS
Two Roller-Smith Co. "Type FD" instruments, an ammeter and a voltmeter, both d.c., on panel of U. S. Light & Heat Corp.'s portable electric welder.



AN INDUSTRIAL RECORDING INSTRUMENT
The Leeds & Northrup "Speedomax" null-method automatically balanced high-speed recording potentiometer pyrometer, employing amplifier and vacuum tubes.

The figures herewith show examples of each of these—which, as is now evident, are "grades" rather than distinct categories. In this scheme of grading, there is no definite place for the industrial instruments with which we are primarily concerned in this volume. In other words, correct instrumentation may call for a delicate and extremely accurate device in one instance, and in another instance for a device which must above all be rugged and need not be an instrument of precision.

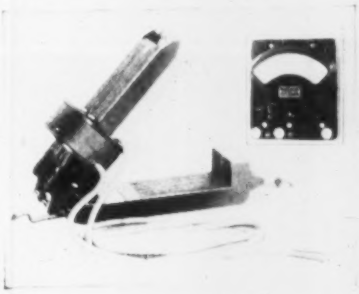
Closely linked with the above classification is that into *forms*: (1) Laboratory, (2) Portable and (3) Switchboard or panel.

Another important classification is based on the measuring functions performed; in other words a classification into "kinds" of instruments (as explained in detail in Part One of this Manual). Here there may be said to be four general classes, as follows:

Indicating, in which the instantaneous value of the measured magnitude is at all times expressed by an indicator or pointer on a graduated scale.

Note: A *detecting* instrument is simply an indicating (or even a recording) instrument used for a restricted purpose.

Recording (or *graphic*), in which a pen or other marking device traces a graph of the values of the measured magnitude upon a moving chart.



ROLLER-SMITH
Type CSO *Split Core*
Transformer Test Set

With this *new* test set the range of measurement is from .5 amp. to 200 amps. Ammeter may be used separate from transformer. Two sizes of ammeters are available.

A compact, rugged, accurate test set.

The price is *right*.

Send for catalog J-123.

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THWING
Treasure Chest

The Thwing Treasure Chest is a highly accurate portable potentiometer for calibrating and checking pyrometers and thermocouples. For general purposes it is used as a direct reading potentiometer.

The Treasure Chest is completely self contained with standard cell, batteries, resistance coil, the Electrocrite and the self-checking feature.

Every plant using pyrometers should have a Treasure Chest.

Ask for Bulletin 16A. 359

Thwing Instrument Company
3323 Lancaster Avenue, Philadelphia, U.S.A.

INSTRUMENTS BOOK SHELF

(Continued from Page 10)

described, the other three being merely mentioned as available.

In the last chapter (XIX), on the use of the thermal conductivity method in scientific research, Dr. Daynes displays his splendid mastery of the subject and gives a profusion of references to interested workers not only in chemical but in biological and medical laboratories. There are three appendices—not tables or reprints but original mathematical developments of the relations laid down in the early chapters. These deal with minimizing temperature and current errors, some properties of the unbalanced bridge, and conditions for optimal sensitivity. Based on Dr. Daynes' rich experience, they will be of value to designers as well as to some users.

The book is excellently printed and handsomely illustrated.

M. F. Béhar (8)-**B**-

MANUFACTURERS' NEW LITERATURE

In this department we each month list the printed matter issued by manufacturers. Unless otherwise noted, any of the items listed may be secured free upon application to the issuing firm. Manufacturers who have not yet sent in their printed matter are invited to do so.

B1 **Automatic Control.** Ingenious cardboard device clarifies operation of "Rotax" automatic controllers. 8-page Bulletin 184 describes them in detail. The Foxboro Co., Foxboro, Mass.

B2 **Microscopes, etc.** Folder entitled "Probing Nature's Secrets." Another entitled "That Christmas Gift for . . ." Bausch & Lomb Optical Co., Rochester, N. Y.

B3 **Laboratory Temperature Control.** Leaflet describes new regulator. Bausch & Lomb Optical Co., Rochester, N. Y.

B4 **Pocket Saving Rule Case.** Leaflet describes combination case and decimal-equivalent table. Brown & Sharpe Mfg. Co., Providence, R. I.

B5 **Radio Transmitters.** 4-page bulletin on Western Electric Co.'s D-95857 Set of Conversion Parts which affords 100% modulation. Graybar Elec. Co., New York City.

B6 **Testing Machines.** 4-page Bulletin 50 describes new Southwark-Heydekampf line. Baldwin-Southwark Corp., Philadelphia, Pa.

B7 **Coal Specialties**. Set of bulletins on coal-pile alarm thermometers, fuel value computer, etc. Arthur T. Ward, New York City.

B8 **Smoke Indicators.** Leaflet describes "Smokgage," etc. Ess Instrument Co., Parkersburg, W. Va.—

B9 **Size Tester.** 8-page bulletin and leaflet on electrical device for determining degree of sizing of paper. Sorg Paper Co., Middletown, Ohio.

B10 **Fuel Gas Analyzer.** Broadside on electric recording CO_2 meter. The Brown Instrument Co., Philadelphia.

B11 **Instrument Transformers.** Folder "Bulletin Ms IVe" on portable current transformers. Herman H. Sticht & Co., New York City.

B12 **Industrial Instruments.** Mechanical Catalog page reprint, and leaflet announcing portable CO_2 set. The Hays Corp., Michigan City, Md.

B13 **Relays.** 24-page catalog containing technical data; also a number of new loose leaves on relays, thermoregulators, etc. Struthers Dunn, Inc., Philadelphia, Pa.

B14 **Potentiometer Pyrometer.** 16-page profusely illustrated Bulletin 190 on new model recorder. The Foxboro Co., Foxboro, Mass.

B15 **Industrial Thermometers.** Leaflet announces new line of recorders and dials. Jas. P. Marsh Corp., Chicago, Ill.

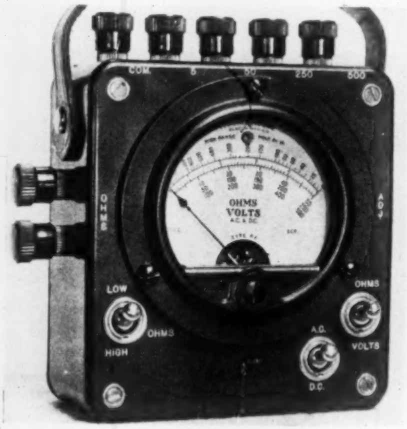
B16 **Cathode Ray Tubes and Oscillographs.** Leaflets and loose leaves announcing new developments in these, in amplifiers, etc. Allen B. DuMont Labs., Upper Montclair, N. J.

B17 **Flow Control.** 16-page technical bulletin on type CD rate-of-flow con-

Integrating, in which there is provided a summation of all the instantaneou values as referred to a time basis, the final result being obtained from the advance of a counting mechanism during the lapse of a predetermined interval o time.

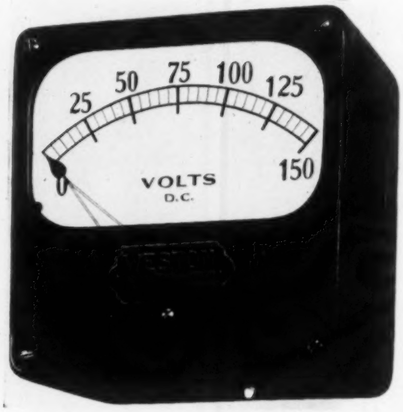
Controlling, in which an electrical measuring element, by means of contact or otherwise, automatically regulates the value of an electrical magnitude, suc as current, voltage or power.

Again, electrical instruments may be classified according to the nature of th electrical magnitude which they are designed to measure. Such a classification in brief, was given in Table I, Part One of this Manual. At this point, it be



TYPICAL PORTABLE INSTRUMENT

A Westinghouse "Type PX-4" multi-purpose and multi-range instrument for general testing work requiring light weight. Net weight 2½ lbs.



TYPICAL SWITCHBOARD INSTRUMENT

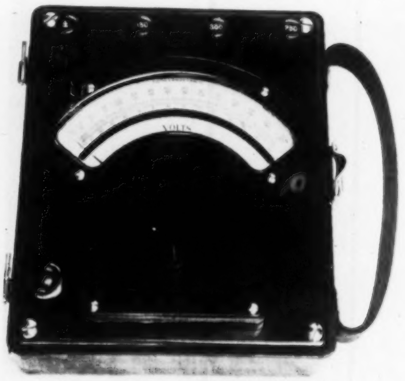
A Weston "Model 502" permanent magnet, movable coil, d.c. voltmeter in rectangular case 5¾ x 6 x 4¼ inches. Scale length 5⅛ inches. Accuracy 1%.

comes necessary to give it in full. In so doing, however, one notes that among the twenty-odd entities involved, there are some which are true magnitudes (truly measureable), and others which are not measurable but merely determinable instrumentally. Examples, Wave Form and Polarity. At any rate, a fairly complete classification of electrical instruments, based on what they measure or determine, now follows:

- Current
- Electromotive Force
- Power
- Energy
- Volt-amperes
- Reactive component
- Power Factor, Phase Angle
- Synchronism
- Wave Form
- Frequency
- Resistance
- Inductance
- Capacitance
- Impedance, Reactance
- Magnetic Field Strength
- Flux Density
- Permeability
- Hysteresis (Iron Loss)
- Polarity
- Misc. Radio

TYPICAL PORTABLE INSTRUMENT

A General Electric "Type AP-9" which may be said to be "intermediate" in size, weight, accuracy and cost. Case is 6½ x 4¾ x 2½ inches. Length of mirror scale (mean arc) 4¼ inches. Accuracy 0.75%.



TYPICAL PORTABLE TEST INSTRUMENT

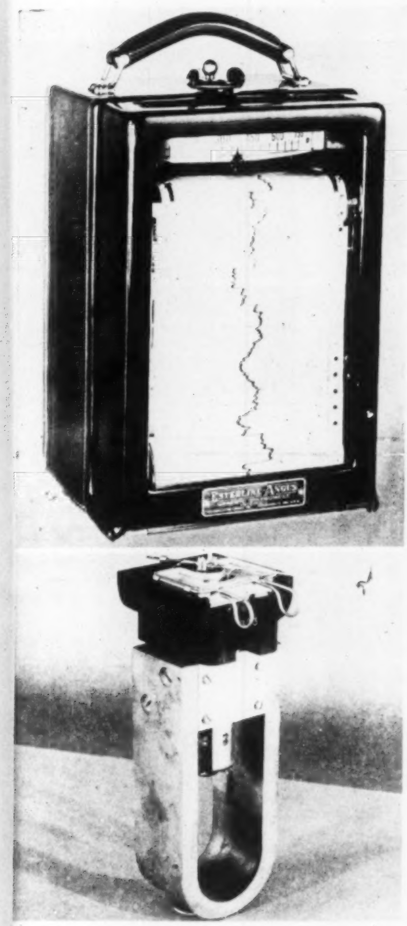
A Westinghouse "Type PX-5" triple-range d.c. voltmeter for general testing in plant or laboratory where accuracy is preferable to light weight. Case is 7¼ x 8 1/16 x 4 inches with cover (removed from hinges in this photograph). 5-inch mirror scale. Accuracy 0.5%.

Still another classification is to be found in the principles of operation, inasmuch as electrical instruments for different purposes may operate on identical principles. This classification (1, electrothermal; 2, electrochemical; 3, electromagnetic; 4, electrostatic) is so far as possible used in the succeeding chapters.

4. Obsolescence

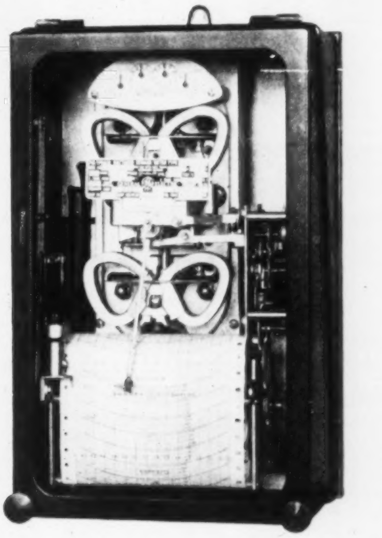
It will be found that there are described some types of instruments which are no longer commercially available; and in explanation of this it may be said that these types are either of distinct technical interest despite their relatively limited application, or else, although now obsolescent, have served such a useful purpose in their day and are still found in such large numbers, as to constitute important elements in the work of the instrumentician. For example, there are in use thousands of old moving-iron and permanent-magnet indicating instruments no longer listed by their makers and which, according to accepted methods of computing depreciation, have been entirely written off as plant assets, but which are by no means of zero technical value. (Yes, we have in mind that old pet of yours in the top shelf!) The technical reason is that most electrical instruments—practically all well-built electrical instruments—grow more dependable with age, in that their drift or creep has become nil so that their calibration is nearly permanent. A word of caution, however: age alone is not a desirable characteristic, and when it comes to selecting instruments, it would be false economy to purchase a random assortment of second-hand instruments instead of the latest models on the market.

These remarks do not apply to watthour meters: the requirements for electricity metering have become so exacting in the last few years that old meters are "obsolete" in every sense of the word even if they are in good condition.



TYPICAL RECORDER
Portable form of an Esterline-Angus "Graphic" milliammeter (also made up in wall and switchboard models) with high-torque d'Arsonval element (shown below). Chart speeds available range from ¾ inch per hour to 1½ inch per second.

A PURELY TESTING INSTRUMENT
The Thwing "Resistometer" is especially designed for testing resistance thermometers, etc. in the plant and laboratory.



TYPICAL COMMERCIAL INSTRUMENT
A General Electric watthour meter combined with a recording demand meter of the "block-interval" type.

trollers. International Filter Co., Chicago, Ill.

B18 **Gyroscope.** 24 page booklet, "Demonstrating the Gyroscope." Sperry Gyroscope Co., Brooklyn, N. Y.

B19 **Time Studies.** Three new folders on Kienzle timing instruments. M. Klein & Co., New York City.

B20 **Combustible Gas Analyzer.** 6-page bulletin describes portable automatic instrument. Bacharach Industrial Instrument Co., Pittsburgh, Pa.

B21 **Excess Temperature Cut-out.** Leaflet HD-1133 describes new form of automatic device. Hevi Duty Electric Co., Milwaukee, Wis.

B22 **Prepayment Meter.** Bulletin 82 describes new prepayment watthour meter. Sangamo Electric Co., Springfield, Ill.

B23 **Liquid Measuring Devices.** Several loose leaves announcing developments in Vol-U-Meters, bottle fillers, etc. Vol-U-Meter Co., Buffalo, N. Y.

B24 **Counters.** Bulletins on pre-determined selective counting devices, etc. Production Instrument Co., Chicago, Ill.

B25 **Liquid Level Gages.** 20-page Bulletin 187 on indicating and recording models. The Foxboro Co., Foxboro, Mass.

INSTRUMENTS, 330 W. 42nd St.
New York City

Please have me supplied with a copy of each piece of Manufacturers' Literature listed below.

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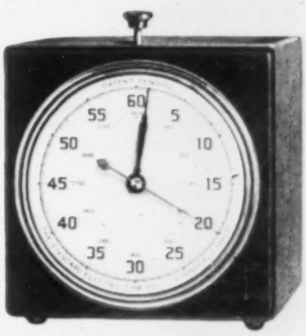
JUST WHAT YOU HAVE WANTED
FOR A LONG TIME

This New Electric
STOP CLOCK



Accurate to better than 1/5 of a second — dead beat—controlled, by convenient switch.

Large 3½" dial—3 times larger than an ordinary stop watch—scale divisions of 1/5 second.

A very practical and ruggedly built instrument — avoids the expense and nuisance of jeweller's repairs.

Makes rapid and accurate readings certain and easy.

Furnished in neat hard wood case, complete with extension cords for connection to current supply, cord with manual control switch and resetting button. Reasonably priced.

**THE STANDARD
ELECTRIC TIME COMPANY
SPRINGFIELD, MASS.**

Write for Prices Please State Voltage and Frequency

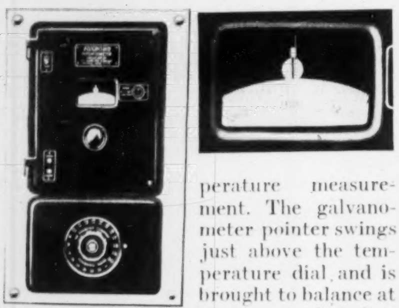
NEW INSTRUMENTS

Write Information Section, Instruments Publishing Company, for additional information.

Indicating Potentiometer Pyrometer

The Foxboro Co.

ALL adjustments are centrally located on the front cover plate of this new instrument, which employs the potentiometer principle of temperature measurement. The galvanometer pointer swings just above the temperature dial and is brought to balance at the same hair-line index which marks the temperature measurement. The hair-line is part of a glass window through which both pointer and scale are viewed at the same time. Thus, balancing and reading are practically one operation. Scale length on the 6" dial is 17", permitting fine divisions, and plain black figures add to the readability. The double-suspension galvanometer is designed to withstand industrial use without impairing accuracy or sensitivity. The new universal moisture-proof case, said to be unique in design, may be either surface or flush mounted. When flush mounted, a clamping device holds the instrument tight to the panel without screws or bolts extending through. Thermocouple leads are brought to a connection compartment, sealed from case interior, and with openings for introduction of conduit if desired. Foxboro multiple-point rotary selector switches may be used to connect any number of thermocouples to the indicator and may be furnished for flush panel mounting as shown in illustration.



"Damplifier" Flow Control

C. J. Tagliabue Mfg. Co.

NOW available with Tagliabue magnetic-coupling flow recorders (*Instruments*, June 1933, page 109), an improved air-operated system of flow control known as the "TAG Damplifier" combines inherently balanced primary elements with amplifying secondary control elements in such manner that, according to the manufacturers, it "makes possible the complete realization of every desirable characteristic of automatic control . . . . will maintain the setting point precisely, even though this may require at times an almost closed diaphragm valve and at other times an almost wide open valve. Under all conditions throttling non-hunting regulation is provided." Essentially, the new system differs from the previous arrangement (of air leak, flapper and capsule-actuated pilot valve) in two respects: (1) Interposition of air flow restrictions, shown on the schematic diagram, Fig. 1, by conventional symbol for electrical resistances. These damp the effects of altered air pressures. (2) A lever system providing a "follow-up" action such as is employed to stabilize some turbine-speed governors and other highly-developed automatic controllers. *Operation:*—A 15-lb. regulated air supply is maintained to ball air valve G. The primary pilot of the control system is a nozzle air leak of usual design, with flapper K positioned by the flow recording pen. Assume a condition when the pen shows that the desired rate of flow is being correctly maintained by diaphragm valve N. Something now occurs causing a decreased flow, moving pen downward. To restore flow to set point now requires a greater valve opening, hence, less air on diaphragm top of valve N. The pen moves flapper K toward the nozzle, decreasing the air escape and quickly increasing the pressure in capsule E which brings lever A upward, causing ball valve G to decrease air pressure to diaphragm valve N. This *decreasing* air pressure now acts on capsule E so that only a small diaphragm valve change takes place. Simultaneously, capsule F deflates very slowly by reason of interposed resistance, lowering fulcrum C of main lever A and moving point O upward (P being the fulcrum in this action) thus slowly amplifying the initial change in position of ball valve G. All this time, gradually decreasing air pressure on diaphragm top of valve N has been opening this main valve, thus increasing the main flow being controlled by the instrument, and gradually moving the recorder pen back to its original position—and with it, of course, flapper K. Equilibrium of the control system is thus restored only when the recorder pen is back at the setting point; that is, when the flow being controlled is restored to the desired rate.

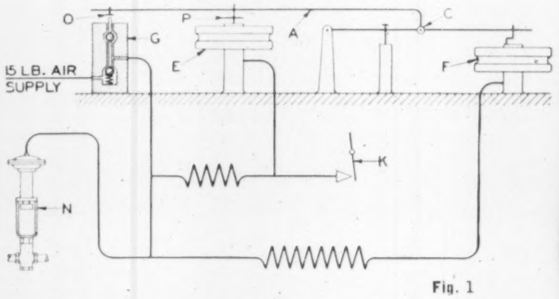


Fig. 1

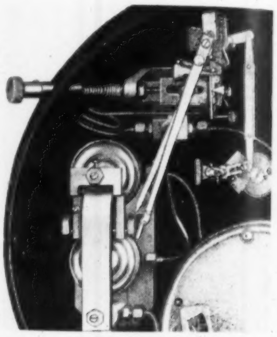
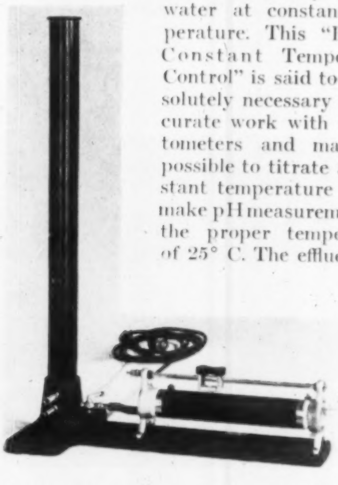


Fig. 2

Effluent Thermoregulator

Bausch & Lomb Optical Co.

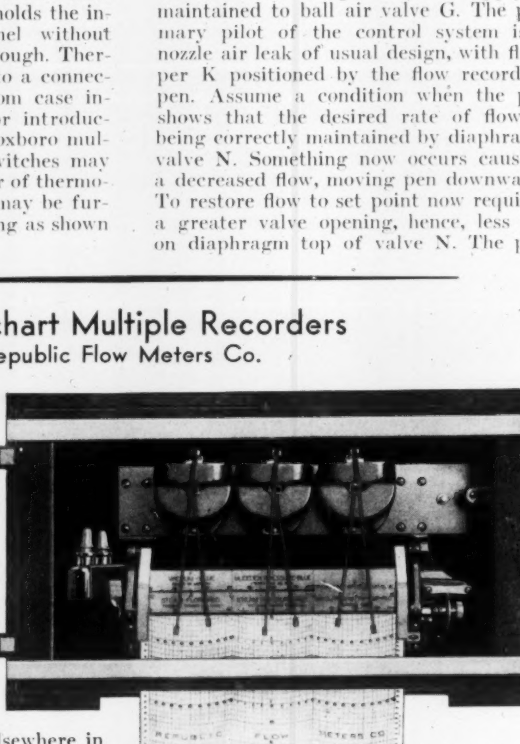
THIS novel equipment combines a constant-pressure tower, a flow-regulating valve, a variable electric heater and related parts, its purpose being to deliver a steady flow of water at constant temperature. This "B & L Constant Temperature Control" is said to be absolutely necessary for accurate work with refractometers and makes it possible to titrate at constant temperature and to make pH measurements at the proper temperature of 25° C. The effluent can be easily held to ± 0.1°C. and published work has been done to ± 0.05°C. Temperature is adjustable from + 5°C. of temperature of input to + 40°C. Service connections required are cold water, drain and 110 volt a.c. or d.c.



Strip-chart Multiple Recorders

Republic Flow Meters Co.

SIX continuous-line records, in three pairs, are produced on the 12" chart of this new instrument. Temperatures, pressures, flows or percents of CO_2 can be recorded in almost any desired combination. Graduations in each of the three zones are evenly divided. Chart drive is by synchronous motor. Chart length is 1500 hours (two months). Individual pen-actuating elements, in pairs, are of the ammeter type described elsewhere in this issue under new Republic flow instruments.



Re-designed Flow Instruments

Republic Flow Meters Co.

SAID to represent "a wholly new conception of instrument design," the individual instruments of this new series, as well as their electrically-operated elements, are standardized, interchangeable, housed in three standard sizes of "cartridges" and easily removed and replaced without disturbing other elements on the same meter panel. For example, Fig. 1 shows a pen-drive element for a recording instrument; Fig. 2 shows it partly slipped into a standard small-size cartridge to form the unit shown in Fig. 3 which, on a meter panel, would be mounted above the chart-drive or "clock" unit, Fig. 5. The indicator unit, Fig. 6, contains an element different from the pen-drive element but fitting into the same small-size cartridge. Fig. 4 shows an integrator unit composed of a standardized element in a standardized large-size cartridge. There are also dual-function units with two independent pens recording two flows; and even triple-function units composed of three independent elements (or of various combinations) in one cartridge. Figs. 7 and 8 show a panel with indicator, pen-drive and chart-drive forming a recorder, and integrator. Numerous standard panels 16" wide are available, also three sizes of "detached" boiler horsepower indicators on panels 16x16", 20x20" and 24x24". Panels are 12-gauge with 1½" roll-back edges; instrument bezels are cast aluminum and project 1½" out from panel. Greatest overall depth is 4" for indicators and recorders; 5" with integrators. Removing units is said to be quite easy: the recorder pen is unhooked, three wires are disconnected, two nuts removed and the entire unit withdrawn, after which the electrically-operated element (Fig. 1) can be inspected. All recorder charts have uniform flow graduations, the conversion from quadratic to linear being accomplished in the resistance type meter body.

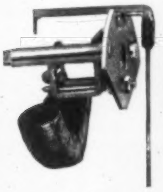


Fig. 1

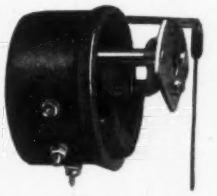


Fig. 2

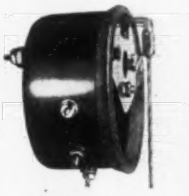


Fig. 3

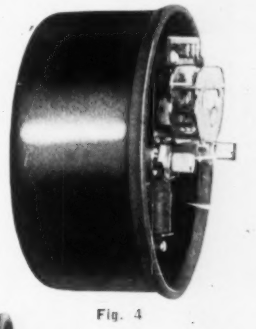


Fig. 4

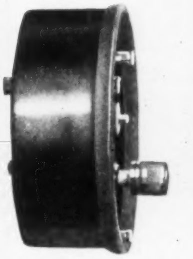


Fig. 5

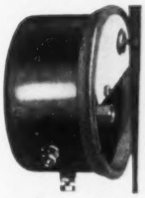


Fig. 6

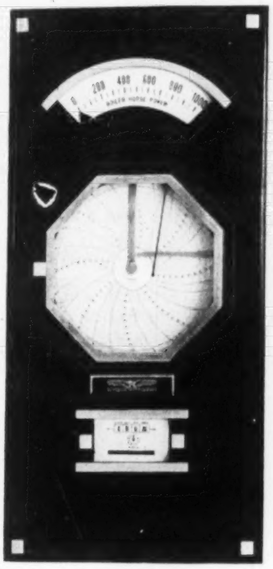


Fig. 7

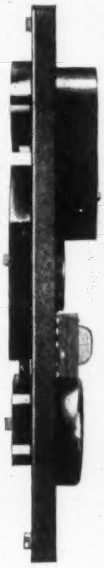


Fig. 8

In the new design the pen adjustment is accessible from the front of the instrument, and the pen is automatically lifted from the chart on unscrewing the chart knob which, being part of the pen release assembly, is always held in position. Indicator and recorder elements are ammeters with the usual restraining spring replaced by an electromagnet. Integrators operate on the watthour meter principle (with an electromagnet instead of a permanent magnet to nullify effects of voltage variations) so that their action is continuous and unaffected by any clock mechanism or mechanical action.

Carrier-current Signal Equipment Finds New Use

General Electric Co.

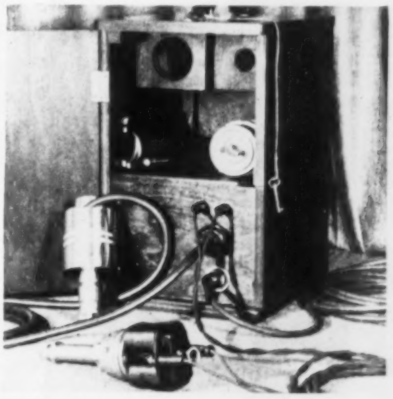
LOAD control is the latest application of carrier-current equipment, the first installation having been made recently in New Hampshire in connection with two fully automatic hydroelectric stations of the Twin State G. & E. Co., known locally as the New Durham and Merrymeeting stations. The output of Merrymeeting is supplied to the system over a 4,000-volt line through New Durham where the connection to the main system is made. An operator living near the New Durham station has supervision over both, with instruments at New Durham to indicate the load carried by Merrymeeting. Starting and stopping of the latter is accomplished by closing or opening the oil circuit breaker in the New Durham-Merrymeeting line at New Durham. A separate cable circuit previously employed in the load control of the Merrymeeting generator became so unreliable that replacement became necessary. A Type GCS single-tube carrier current signal transmitter was installed in the New Durham station, and a Type SCS double receiver with coupling capacitors at Merrymeeting. A coupling to one phase of this 4,000-volt line with ground return is being used. The two elements of the double receiver operate on opposite half waves, and consequently their independent actions depend on the relative instantaneous polarity of the supply voltage to the transmitter and receiver. Permanent connection to the supply voltage (110 volts, 60 cycles) is made at the receiver, and a standard double-pole double-throw governor control switch is used to reverse the supply connection to the transmitter. Each element of the double receiver controls the operation of the motor-operated gate-limit control, one element to open the gate and the other to close it.

The above is of interest as suggesting futher possibilities. The distance is not stated but carrier-current equipments are rated at 40 db., corresponding to 200 miles over a clear 46-kv. transmission line. In connection with ground return mentioned above it must be noted that carrier-current equipments operate best when a full-metallic circuit is used as the path for the carrier-current. The two-wire metallic circuit used as a path should be free from direct grounds. If it is broken by apparatus which form a high series impedance at carrier frequencies, by-pass equipment can be employed to transfer the carrier energy around such obstructions.

Engine Compression Gage

Commercial Engineering Labs.

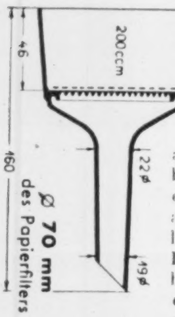
GIVING dependable readings of compression pressures at all speeds, the Research Compression Gage operates on the same principle as the Research Engine Indicator (*Instruments*, December 1933, page 233), except that the pressures are read from an indicating pressure gage instead of being recorded on a chart. The standard pressure element is mounted in the cylinder, usually in the spark plug opening, and the small synchronizer interchanges with the distributor. When required, the synchronizer is so constructed that it can be mounted between the engine and the distributor so that the engine can be operated under its own power. This arrangement permits compression readings to be taken in one cylinder while the others are in operation. The ignition type pressure element can be used and maximum explosion pressures obtained while the engine is undergoing tests.



Buchner Glass Funnels

Fish-Schurman Corp.

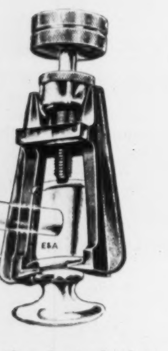
INTO a glass funnel is fused a glass disk provided with numerous uniformly-spaced slits which are narrower at the top than at the bottom. Each size of funnel fits a given size of filter paper, which consequently lies flat without tearing. All glass is transparent, highly resistant to acids and alkalies, and will not crack when boiling water is poured on. Rapid filtration is assured by reason of large filtering surface. Residue can be detected by reason of transparency. Close fits of papers in corresponding funnels prevent side leakage. Five sizes are available. These new Buchner funnels are produced by the Glaswerk Schott & Gen., Jena.

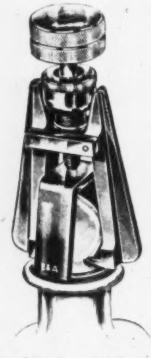


Universal Stopper Remover

Eimer & Amend

SAVINGS of valuable apparatus, time and nerves will result from the use of this combination stopcock plug and bottle stopper remover, said to be the first device of its kind which is not only adaptable to all sizes but applicable to stopcock plugs (Fig. 1) and to "frozen" bottle stoppers (Fig. 2).

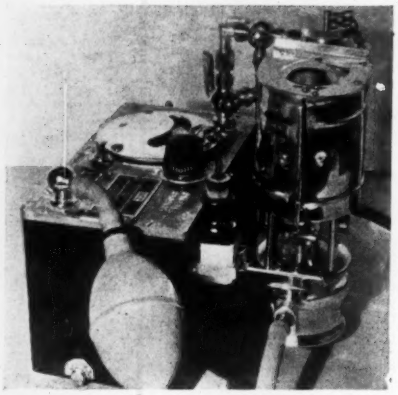




Wide-range Flow Meter

Republic Flow Meters Co.

TO meet the requirements of installations where wide flow variations must be measured accurately there has been developed a wide-range meter, consisting of one orifice with two meter bodies (3 to 1 capacity ratio) connected in parallel, and two sets of instruments: one set operating electrically from the high-range body and the other from the low-range body. Two pilot contacts in the low-range body actuate a relay whereby at low flows (below a definite rate) connection is only made to the low-range set of instruments, and above the change-over point only to the high-range set. Thus the instantaneous rate is always indicated or recorded on the more suitable of two indicators or of two recorders; and the sum of the areas on the two charts (using separate factors) represents the total flow, which may be checked against the sum of the registration increments on the two integrators.



All-service Gas Indicator

The Linde Air Products Co.

THIS latest addition to the Linde gas indicating equipment supplements two other indicators, the U.C.C. Methane Detector and the U.C.C. Combustible Gas Indicator. Designed primarily for the manufactured gas industries, it does three things: (1) Indicates how flammable or explosive an atmosphere is; (2) shows the presence of poisonous gases and vapors; and (3) indicates any deficiency of oxygen. It can be used with absolute safety for testing manholes, locating underground leaks, and in purging. Like the earlier instruments, it is equipped with a body harness, is complete, is ready for instant use and is said to be simple to operate.

Triple-range Optical Pyrometer

Pyrometer Instrument Co.

THREE scales are incorporated in this new model "Pyro" optical pyrometer: a low-range scale (1400° to 2200° F.) and a high-range scale (1800° to 3400° F.) for black body conditions, and a third scale (2200° to 3600° F.) said to be corrected for reading molten iron and steel in the open.

High-speed Micro Switch

Production Instrument Co.

HALF an inch-ounce of energy is more than ample to operate this new device, chiefly used in circuit with a magnetic counter, to count transparent or extremely light objects without resorting to the use of photocells. It is standard equipment for counting Pullman tickets on a Hall folding machine. The straight spring arm shown in the illustration may be replaced by a curved spring arm, for sliding contact, and the switch is then used on such applications as stopping a rotary printing press when the web breaks, giving a signal or stopping a textile machine when a single thread breaks, etc. Rating is 50 watts; highest sustained speed reported in all-day counting service is 417 per minute.

Inspection Polariscope

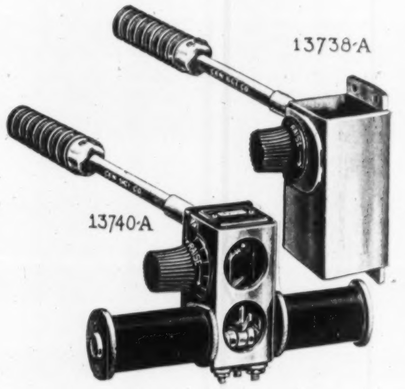
Bausch & Lomb Optical Co.

FOR viewing strains in finished glass products, estimating their degree and marking their location, this new instrument employs a concave polarizing plate of black Carrara glass evenly illuminated through a ground glass window; a calcite prism combined with a retardation plate for analyzing; and a high-intensity illumination unit (obtainable separately for use with old model polariscopes). Visible sample area is 4 in.² and the curtained space permits introduction of bottles or other samples up to 15" across. This new instrument makes it possible to detect strains in colored and in semi-transparent glass objects.

Contact Thermoregulators

Central Scientific Co.

BIMETALLIC types of temperature control units recently announced include these two: No. 13738A is a De Khotinsky design, single-pole double-throw unit for use in air chambers. Each of the two opposed stationary contacts will break a 300-watt load. Used with mechanical latch, electrical reset types of relays for heavy heater loads. No. 13740A is described as a "positive unvarying temperature control" (patent applied for). This thermoregulator is of the single-throw double-pole type equipped with electromagnetic controls for the pressure of the contacts. The mechanical latch relay (not illustrated) operates 0.008 sec. after the slightest contact is made by the thermoregulator contacts, whose function is only to close the circuit, never to open it. Thus, an extremely small differential is permissible. The unit is free from chattering from mechanical vibration. Loads up to 30 amps. may be controlled. This unit is said to be suitable for industrial applications as well as laboratory ovens and baths.



Laboratory Ovens

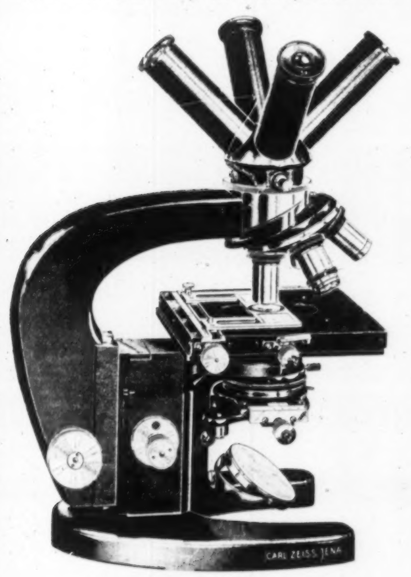
Freas Thermo-Electric Co.

TEMPERATURE gradients are minimized by horizontal-flow circulation in this new series of mechanical convection units equipped with Freas thermoregulators of a new type as well as with indicating thermometers. Three sizes (from 1 to 9 cu. ft.) are each available in three short temperature ranges (room to 70°C., 70 to 180°C. and 150 to 260°C.) permitting extremely close control; longer ranges are optional, with sensitivity proportionately less. Modernized designs and stainless-steel wall construction are among improvements.

Convertible Microscopes

Carl Zeiss, Inc.

IN designing the new "L" Stand, particular attention was paid to comfort of observer, whose wrists can rest on the bench while he makes all adjustments. Image sharpness, affected in old designs when actuating focusing heads, now remains undisturbed. The deep recessed limb facilitates examination of large objects. Slow motion is twice as sensitive as before. By means of the tube-changing device the following interchangeable components can be used: (1) inclined monocular tube; (2) inclined binocular tube; (3) straight extensible tube for photographing, drawing, etc.; (4) quadruple eyepiece revolver; (5) epi-bar for objects too large to be mounted on stage. Moreover, the "L" Stand can be equipped with various stages and with various types of illuminating apparatus, making possible numerous different combinations.



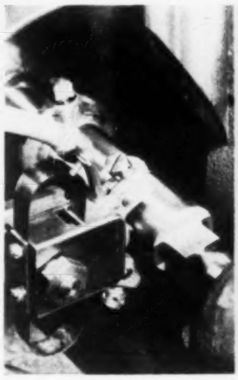


Fig. 1

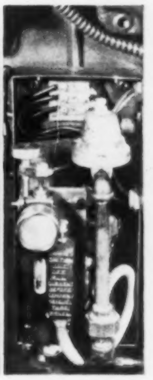


Fig. 2

Air-operated Work Sizer for Grinding Machines

Landis Tool Co.

AUTOMATIC sizing, in connection with precision grinding operations—both external and internal, and regardless of character of surface—is the purpose of a line of new instruments, of which one model is illustrated. Operation of the "Landis Air Sizing Device" is based on the changes of pressure in an air line (due to variations in the size and shape of the discharge opening) producing changes in mercury level in a U-tube, which constitutes a mercury switch controlling feeds and other machine movements. Fig. 1 shows a typical external grinding sizing head. The air outlet is between two diamond points which the oval spring causes to rest lightly on the work. As grinding proceeds, the air pressure builds up, causing mercury to rise in the front tube of the control box, Fig. 2, and close one contact whereby feed-in speed is reduced. Grinding continues until finish size is reached, when a second contact causes the wheel to move rapidly away from the work.

Magnetic Thickness Gages

Commercial Engineering Labs.

EMPLOYING the same principle of measurement of thickness of magnetic metals and alloys as the regular model (*Instruments*, November 1933, page 212), these new "Micro-Magnetic" Thickness Gages have one electrical indicating instrument instead of two. In operation, a selective switch permits taking readings at either of two points. One of the new models is for use on outside of cylinders or tubes (or on flat or curved plates); the other is for insertion in engine blocks, etc., for measuring wall thickness from inside.

Mercury Thermoregulator

American Instrument Co.

UNLIKE the usual Beckmann or reservoir type of thermoregulator, this new sealed mercury device may be set at the desired operating temperature without resort to any trial-and-error method. Procedure is as follows: Bulb is immersed in liquid which is at exact temperature at which regulator is to operate; time is allowed for all of mercury in bulb to come to this temperature; surplus mercury (above upper contact) is spilled off into side reservoir by quick tipping motion. Regulator is thus set within 0.02°C. Operating sensitivity is said to be $<$0.01° C. Setting is undisturbed by exposure to 20° C. excess temperature. Manufacturer recommends that this regulator be used with a relay using $<$ 10 milliamperes, such as "Aminco Supersensitive Relay" (*Instruments*, Oct. 1933, page 197).

"Type Z" Instruments

Herman H. Sticht & Co.

THIS new Siemens & Halske line is said to have several distinctive features. Shunts are arranged to slip directly under binding posts on all capacities up to 20 amp. Multi-range dial shunts (Fig. 1) are used on capacities above 20 amp. Some millivoltmeters are made up in combination for current and potential measurements, with range of 10 ma. and 100 mv., special plug type multipliers being used for voltage measurements. For high-frequency work the d'Arsonval instrument has a range of 10 mv. and 0.2 ma. and thermocouple converters sliding under binding posts are available for full-scale ranges from 5 ma. to 10 amp., also vacuum thermocouples for from 5 to 100 ma. For potential measurements instruments are also supplied with self-contained thermocouples with ranges of 10 ma.; plug type multipliers for 1.5 to 300 volts are also available.

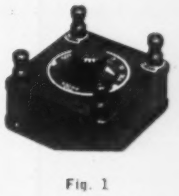


Fig. 1

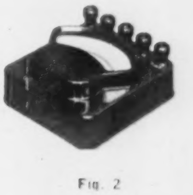


Fig. 2

In this Section we strive to present ALL the news of devices for measurement, inspection and automatic control, in the form of concise technical descriptions. Most descriptions are written by our own engineering staff; some are prepared by manufacturers and carefully censored. NONE IS PAID FOR, DIRECTLY OR INDIRECTLY.

When writing to manufacturers directly, please mention this Section as your source of information.

Recorder-controllers with Mercury Switches

The Brown Instrument Co.

COMPLETE separation of measuring and control functions is said to have been achieved in these temperature, liquid level or pressure recorder-controllers. As recording instruments they have the appearance and the construction features of the new Brown recorders described elsewhere in this issue. As controllers they are mercury-switch instruments having a capacity of 15 amps. at 110 volts (10 amps. at 220 volts) which makes relays unnecessary in most applications, the switches being motor-operated so that no power is required of the thermal or pressure helical spring. The mechanism which makes this independence possible is shown in annotated photograph, Fig. 1, and schematic diagram, Fig. 2. Control segment D including neutral step segment C moves with pen A. Secondary pointer F, attached to control point index B, is depressed once every 6 seconds by depressor lever E (which is moved down by operating cam G and returned up by spring S) and contacts segment D at point R. The elevation to which F returns after being depressed depends on whether point R contacts D at M or N or misses it entirely at P. N is the "neutral" step; its width is adjustable from zero to 50% of the scale range.

When B is directly under A, R contacts extreme right edge of M; if A is slightly above B, F slips past M and strikes N; if A is above B to an extent greater than neutral width, F slips past N to its maximum position which is the third or "high" step. The elevation of F in turn position switch selector H (mounted behind control mechanism base plate, not visible in Fig. 1). Every 6 seconds this switch selector is raised by cam G and contacts pawls T (which protrude toward rear of instrument) thereby positioning mercury switch L in one of three positions depending on extent of elevation of F. The result is that the mercury in the switch "follows the pen": If pen is to left of control index, mercury flows to left; if A is to right of B, mercury flows to right; when A shows that correct temperature, pressure or level is being maintained, mercury is in center of switch. Pen A, actuated by helix, bellows or diaphragm of measuring system, is therefore as free to travel as if it were part of a non-controlling recorder, except for a moment every 6 seconds when F contacts D; and parts F, H, etc. merely "transmit the command," the power for moving the switch coming from motor-driven cam G. Switch is mechanically locked in place until a new position is required.

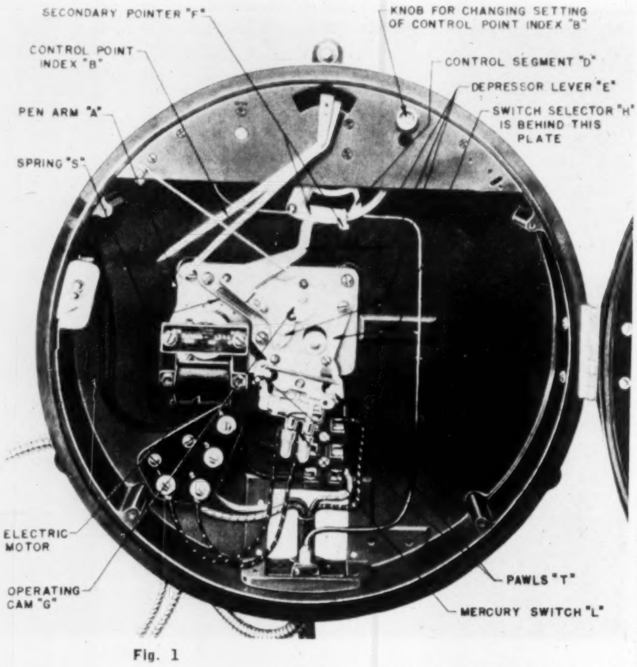


Fig. 1

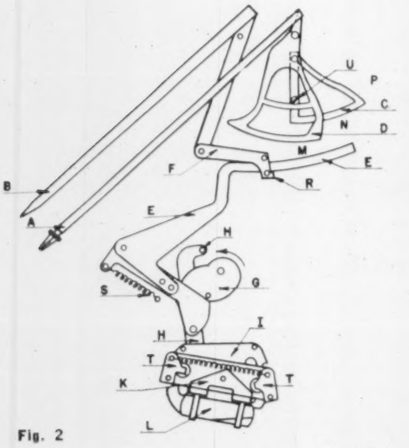


Fig. 2

Non-recording Controllers. In addition to above-described line, manufacturers announce also round-case indicating controllers embodying same measuring systems and control mechanisms. Scales are 6" long, with figures readable from > 10 ft. Instruments can be furnished to flash lights or sound audible alarms.

"Arc Arrester" for Industrial Contactors

Westinghouse Elec. & Mfg. Co.

WITHOUT introducing mechanical devices to suppress the arc it is possible to speed a.c. arc extinctions with a simple single-break type of contactor by mounting an "arc arrester" on its base. This new device is a small unit consisting of a small capacitor and resistor connected across the poles on the load side of the contacting device. Its effectiveness is said to be startling: Oscillograms of tests at 550 volts, 60 cycles with a 7½ H.P. motor, rotor locked, as load, show less than one-half cycle arcing with the arc arrester as against a persistence of five to eight half cycles without it. In practical installations but one unit is required for a 3-phase contactor, and relief is afforded also for any disconnect, operating switch, fuse or other rupturing device connected ahead of the contactor or linestarter. On 3-phase reversing service but one arc arrester is required as it acts with equal effectiveness to relieve either the forward or reversing contactor.

Universal Testers

Shallcross Mfg. Co.

PAST, present "and future" radio sets can be analyzed, it is said, by means of the new No. 611 universal tester, which has the following ranges:

D.c. voltage range (1000 ohms per volt)	5-25-100-250-1000 volts;
D.c. current range	1-10-100-1000 m.a.;
A.c. voltage range (1000 ohms per volt)	5-25-100-250-1000 volts;
Resistance (d.c.)	0.5-5,000,000 ohms;
Resistance (a.c.)	25-3,000,000 ohms;
Capacity	.001-10 mfd.;
Inductance	100-10,000 henrys

The No. 611 can be used by itself for point-to-point testing when chassis is removed from cabinet. For those who prefer the type of analyzer using adaptors there has also been brought out No. 611A, which is a boxed set with analyzer panel in the lid whereby all tubes can be taken.

Excess Temperature Cut-out

Heavi-Duty Elec. Co.

PROTECTING the charge rather than the heating equipment, this new instrument may be set to cut-out a few degrees above normal operating temperature. A separate thermocouple in the

HEVI-DUTY
EXCESS TEMPERATURE CUTOUT
START BUTTON
TIMER
HEVI DUTY ELECTRIC CO.

heating chamber actuates the cut-out relay in the circuit which controls the source of heat—gas, oil or electric. Failure of thermocouple opens the control circuit. Pilot light shows whether cut-out circuit is open or closed. Where no automatic control equipment is used the device may be connected to flash a signal light or sound an alarm when temperature becomes excessive.

Electric Contact Gages

The Hays Corp.

COMPACT electric contact gages for draft, pressure and differential draft or pressure in ranges between 0.1 and 100" water and employing the Hays dry type actuating unit, are offered for either high or low contact service or for both, equipped with closed mercury switches or open contacts. Cast aluminum case accommodates either one or two single or double contact units or a single or double contact unit and a second unit which indicates pressure or draft on a 3" scale. For differential draft or pressure the case is made air-tight. Principal service: applications where it is desired to sound an alarm or light a bull's-eye at predetermined high or low points. Also, in conjunction with intermediate devices, to open and close dampers, start and stop fan or vibrator motors, etc.

0-2 4 6 8 1
HAYS

New Cathode Ray Tubes

Hygrade Sylvania Corp.

IN electrical and industrial work new cathode ray tubes are finding important niches, particularly for oscillograph or wave form studies. "Our research and engineering activities have been mainly along the line of producing a satisfactory vacuum type cathode ray tube," states O. H. Biggs, who heads the research activities of the Salem Division of the Hygrade Sylvania Corp., "in contrast to the usual gaseous type. While the vacuum type tube is more difficult to make and also requires higher operating voltages, it has greater stability and longer life. New refinements are principally in the form of extra control electrodes for focusing the beam at the point of impact on the fluorescent screen. [This feature is essential in such critical applications as television reception.] We have developed our latest tubes along the line of good optical practice. Knowing what lenses are required to intercept, concentrate, modulate and then impinge a beam of light to a point focus on a screen, such as in motion picture projection, we have virtually duplicated the optical system in electrical terms. Our electrical lenses are static and magnetic fields whereby we control the cathode ray beam as though it were a light beam."

Recorders with New Design Features

The Brown Instrument Co.

1. Recording Thermometers

OUTWARD appearance remains unchanged except for a chromium-plated combination door handle and lock. New die-cast aluminum case is "universal"—flush or front-of-board, and with bottom or back connections interchangeable. Greater accuracy is said to be attained through (1) new form of helix which can unwind without causing side pull on shaft, free end being connected to shaft by flexible metallic strip, eliminating "tapping error" and increasing ultimate sensitivity; (2) more powerful helices, increasing pen torque; (3) micrometer calibrating screw for close final adjustment; (4) charts printed from wax engravings under controlled humidity and temperature conditions, said to have no "chart error" and to have longest pen travel of any charts of corresponding diameters. Better suitability for severe service is claimed by reason of factors making for ruggedness: (1) helices heat-treated against fatigue [at end of a test consisting of 100,000 full-scale deflections at rate of 37 cycles per minute, there was no change of calibration and no sign of approaching failure]; (2) helix, pen arm and link are simple, without delicate adjustments and built to withstand 100% overload; (3) improved case, gasket, cam action handle, large hinge with stainless steel pin, etc.

Among other new features stressed in maker's special technical report to this department are: (1) Thermal systems removable from instrument, spares can be stocked and installed without time loss, range can be changed or instrument converted to 2-pen or 3-pen in the field. (2) Electric clock now standard at no extra cost; chart drive switch, also standard, is accessible yet under lock and key. (3) Quickly replaceable fountain pen. (4) Chart knob elimination saves time when changing charts; with new device, records cannot be faked by holding pen at desired temperature and spinning chart by hand. (5) Mercury-expansion thermal systems now available [in addition to gas, liquid and vapor pressure] are compensated for head error; tube coefficient is said to be negligibly small.

These new instruments are available in 10" and 14" cases (8" and 10" charts), with a now fully complete line of tubings, bulbs, fittings and accessories.

2. Special Recording Thermometers

PORTABLE models are announced with above-mentioned features, in 10" case, with any desired thermal system and bulb fittings, or self-contained. Removable legs and handle are said to be an exclusive feature.

For dairies there are announced 10" and 14" white enameled case recorders with special sanitary fittings and with special charts for pasteurizers.

3. Pressure and Vacuum Recorders

IN addition to new features corresponding to those of recording thermometers, a new type of pressure element is announced, consisting of a one-piece hydraulically formed metal bellows balanced against a helical steel spring held in a cup set down in the center of the bellows. This movement, designed for pressures between 10 and 200 lbs./in.^{2}, provides ample pen torque (15 to 25 times that obtainable with a helical pressure spring) so that when a change of pressure occurs the pen moves to its new position "with a positiveness that seems incredible . . ." Rapid pressure fluctuations, however, will not cause improved pen to spill ink, it is said.

4. Liquid Level, Etc.

THE above-described instruments, with various appropriate primary elements, are made up for recording liquid levels, positions, etc. Numerous styles of charts are available.

5. Recording Hygrometer

SIMILAR in some other respects to the recording thermometers described above, this new instrument employs for its primary element a number of strands of human hair in a perforated metal guard. Two-pen models are available, the second pen recording temperature. Standard 8" chart is graduated 0 to 100% relative humidity.

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INSTRUMENTS ABSTRACTS

MEASUREMENT & CONTROL (2)

Flow & Volume (2.05)

Gas and Water Meters and Their Influence on the Piping System. (Die Gas- und Wassermesser und ihr Einfluss auf le Rohrnetzverluste.) *Das Gas- und Wasserfach,* Vol. 75, Feb. 20, 1932, pages 146-148.

Describes method used for testing gas and water meters every 4 years. Tests are made on the materials and their usefulness in the future with respect to operation and maintenance costs in their respective gas and water systems. MAB (2.05)

Devices to Prevent Pipe Failures. (Rohrbruchsicherungen.) G. Eggers. *Gas & Wasserfach,* Vol. 74, Aug. 1, 1931, pages 724-731.

Automatic and semi-automatic protective devices, their principles, and applications. Choice of shut-off fittings. Switches dependent on velocity of flow. Tilting manometers. Flow-meters with maximum contact. Differential flow-meters. Automatic safety pressure switches. Manometer with minimum contact. 12 figs. EF (2.05)

Periodical Checking of Gas Meters. (Periodischer Nachschau der Gasgeraete.) R. Nuebling. *Gas & Wasserfach,* Vol. 74, Nov. 7, 1931, pages 1038-1039.

Author urges it. EF (2.05)

The VDI-Rules for Flow Measurement with Standardized Nozzles and Plate Orifices. (Die VDI-regeln fuer die Durchflussmessung mit genormten Duesen und Blenden.) K. Bunte & L. Zipperer. *Gas & Wasserfach,* Vol. 74, March 14, 1931, pages 250-254.

The writers cover the following: I. Theoretical principles. II. Description of the V.D.I. standardized nozzles and thin-plate orifices. III. Quantities passing, permissible deviations and corrections. 7 figs. EF (2.05)

The New Gas Meter of Brandl-Marischka. (Der neue Grossgasmesser System Brandl-Marischka.) Brandl-Marischka. *Gas-& Wasserfach,* Vol. 74, Jan. 17, 1931, pages 67-68.

Controversy between the inventors and the Pittsburgh Equitable Meter Company on the instrument. EF (2.05)

The Gas Meter of the E. Eickhoff Company, Wuppertal. (Die Gasmessmaschine der Firma E. Eickhoff, Wuppertal.) E. Eickhoff. *Gas & Wasserfach,* Vol. 74, July 18, 1931, pages 686-687.

Supplementary remark to the paper of Weymann abstracted above. Presents authentical data disclosing the possibility of holding the error limit within ± 1% in contrast with Weymann's statements. EF (2.05)

Modern Gas Distribution and Gas Meters. (Moderne Gasverteilung und Gasmessung.) L. Niessen & B. Ludwig. *Gas & Wasserfach,* Vol. 74, Aug. 15, 1931, pages 776-777.

Controversy precipitated by a previous article of Ludwig. (*Gas & Wasserfach,* Vol. 73, Dec. 20, 1930, pages 1201-1207.) ary gas meters and 7 over ordinary gas meters. EF (2.05)

The Gas Meter of the E. Eickhoff Company, Wuppertal. (Die Gasmessmaschine der Firma E. Eickhoff, Wuppertal.) O. Weymann. *Gas & Wasserfach,* Vol. 74, May 9, 1931, pages 431-432.

Measurements sponsored by the Physikalisch-Technische Reichsanstalt, Berlin, on the Eickhoff gas meter which is intended for the measurement of large gas quantities. (2000 m^3 per hour, 2000 r.p.m.) 5 advantages over stationary gas meters and 7 over ordinary gas meters. EF (2.05)

Reynolds' Number for Orifice Metering—Approximate Formula. (Reynolds'sche Zahl fuer Blendenmessung, Naeherungsformel.) L. Zipperer. *Gas & Wasserfach,* Vol. 74, Nov. 28, 1931, page 1101.

Derives approx. formula. EF (2.05)

Temperature (2.06)

Temperature Measurement of Air and Water on the Ocean and its Significance. (Temperaturmessung von Luft und Wasser auf Dem Ozean und ihre Auswertung.) J. Moeller. *Die Messtechnik,* Vol. 8, April 1932, pages 78-81.

The meteorological measurements made on the surveying ship "Carnegie" are described, in particular those of air temperature. It was noticed that the latter when measured on a ship in summer time or in the tropics, are usually too high. Precautions have to be taken to avoid errors due to local overheating of and radiation onto instruments. The water of the ocean exerts an enormous influence on the atmosphere. Ha (2.06)

The Regulation of Temperature in Vulcanizers. (Ueber die Regelung des Temperaturverlaufs in Vulkanisierkessein.) C. Himmler. *Siemens-Zeitschrift,* Vol. 12, March 1932, pages 97-102.

Temperature control in the rubber discussed and resistance thermometry described; temperature charts are reproduced. Ha (2.06)

A New Micro Furnace for Temperatures Higher than 1000°C. (Ueber einen Micro-Ofen fuer Temperaturen oberhalb 1000°C.) H. S. Roberts & G. W. Morey. *Zeitschrift fuer Instrumentenkunde,* Vol. 51, July 1931, pages 385-386.

Mainly consists of a ⊔ shaped Pt-Po strip 0.01 mm. thick. Features are low thermal inertia and quick rate of cooling. The melting temperature is determined by optical pyrometry. EF (2.06)

Porosity of Ceramic Pyrometer Tubes in Relation to Temperature. (Die Gasdurchlaessigkeit von keramischen Pyrometerrohren in Abhaengigkeit von der Temperatur.) Immke. *Tonindustrie Zeitung,* Vol. 55, Feb. 21, 1931, page 149.

The permeability for gas is given at 20°, 1000° and 1500°C. for pyrometer tubes of 6 different materials. EF (2.06)

Universal Calibration and Testing Apparatus for Thermometers with Electric Heating and Stirring Device. (Universal-Justier- und Pruefungs-sowie Alterungsapparat fuer Thermometer mit elektrische Heizung und elektrische Ruehrvorrichtung.) *Glas & Apparat,* Vol. 12, Feb. 22, 1931, pages 27-28.

Auxiliary equipment for measuring technique. Manufacturer: Gotthold Koechert & Sons. EF (2.06)

Pyrometers Placed upon the Surface of Solid Bodies. (Anlegepyrometer.) W. Claus & R. Hase. *Zeitschrift fuer Metallkunde,* Vol. 23, April 1931, pages 120-123.

Necessity of temperature measurements on surfaces of solid bodies. Theoretical conclusions. Necessary instruments. EF (2.06)

Nickel-Iron Alloys in Temperature Control. *Nickel Bulletin,* Vol. 5, May 1932, pages 105-106.

Thermostatic switch operated by a bi-metallic strip, one element a Ni-Fe alloy with 36% Ni which has a practically negligible coefficient of thermal expansion up to about 200 C. A few thermostats are described. Ha (2.06)

Temperature Measurements on Electrodes in Motion. VI. (Temperaturmessungen an arbeitenden Elektroden.) B. Bruzs. *Zeitschrift fuer physikalische Chemie,* Section A, Vol. 156, Oct. 1931, pages 279-290.

A dynamic calorimeter with a temperature sensitivity of 1.8x10^{-6} degree/mm and a Peltier thermal sensitivity of 4.5x10^{-7} watt/cm^2: mm is described. EF (2.06)

Temperature Measurements on Electrodes in Motion. V. (Temperaturmessungen an arbeitenden Elektroden V.) B. Bruzs. *Zeitschrift fuer physikalische Chemie,* Section A, Vol. 155, Aug. 1931, pages 392-402.

Theoretically proves the Peltier effect to be identical with the latent heat of the electrode process, presumably the electrodes are reversible. EF (2.06)

A New Thermo-Regulator for Adiabatic Calorimeters. (Ein neuer Thermo-regulator fuer den Betrieb von adiabatischen Kalorimetern.) H. Rieche & R. Grau. *Zeitschrift fuer technische Physik,* Vol. 12, May 1931, pages 284-286.

A thermo-regulator was designed for adiabatic calorimeters used in the fields of inorganic chemistry and high-frequency calorimetry. Suitable for research work with exothermic or endothermic effects. EF (2.06)

The Experimental Foundation of the International Temperature Scale in the Range of Low Temperatures. (Die Experimentelle Grundlagen der internationalen Temperaturskala im Bereich tiefer Temperaturen.) W. H. Keesom. *Zeitschrift fuer die gesamte Kaelte-Industrie,* Vol. 38, Feb. 1931, pages 20-31.

The well-known author critically discusses a previous paper by F. Henning abstracted above. EF (2.06)

Heat and Combustion (2.07)

Thermal Conductivity of Crystalline Boiler Incrustations. (Waermeleitfaehigkeit von kristallinen Kesselsteinen.) P. Zarnitz. *Die Waerme,* Vol. 54, Oct. 10, 1931, pages 756-761.

The author designed, for this doctor's thesis, an equipment for testing the heat conductivity of crystalline boiler incrustations. By use of this apparatus he found that the thermal conductivity depends solely on the kind of crystalline structure and not on the density of the incrustation (=Raumgewicht) as is the case with amorphous incrustations. EF ((2.07)

Development of the Calorific Value Determination of Solid Fuels. (Zur Entwicklung der Heizwertbestimmung fester Brennstoffe.) K. d'Huart. *Die Waerme,* Vol. 53, April 26, 1930, pages 313-317.

The author reviews historically the calculation method on one hand and the calorimetric determination on the other hand with respect to developments in Germany. He also points out the correlation of the calorific value to the amount of air required for the combustion and critically considers French publications. 24 references. EF (2.07)

Flue Gas Testing. (Rauchgasprüfung.) H. D. Brasch. *Die Waerme,* Vol. 54, Jan. 17, 1931, pages 57-59.

While flue gas tester based on physical principles may lead to false conclusions, a decided lack of chemical flue gas testers, which are rather insensitive to the large fluctuations of plant conditions, was felt up to the present. These difficulties are largely overcome by the recent Duplex Mono which is fully described and illustrated. EF (2.07)

Graphical Testing of the Combustion Process. (Graphische Bestimmung des Verbrennungsvorganges.) A. Nachoczky. *Die Waerme,* Vol. 54, March 28, 1931, pages 231-235; Vol. 54, April 4, 1931, pages 250-254.

A new method is given which yields the Ostwald Waste Gas Diagram without calculation and knowledge of the fuel composition. The influence of the incidentally present H_2 and CH_4 is discussed with respect to the adaptability of the diagram. EF (2.07)

Automatic Combustion Control Systems for Wire Furnaces. Part II. F. Aschner & H. Mayer-Witten. *Wire & Wire Products,* Vol. 6, Sept. 1931, pages 363-365.

The importance of automatic furnace control, particularly in the manufacture of wire, is pointed out. Economy of the process and quality of the product depends largely on the furnaces. This installment describes temperature control and pressure control apparatus used in German installations. See *Instruments,* Vol. 5, Mar. 1932, page A15. Ha (2.07)

A Simple and Safe Method of Indicating the Melting Properties of Coal Ash. (Eine einfache und sichere Methode zur Kennzeichnung des Schmelzverhaltens von Kohlenaschen.) M. Dolch. *Die Waerme,* Vol. 54, April 4, 1931, pages 255-257.

The deficiencies of the Burgess Apparatus for ash melting point determinations are pointed out and modifications on the equipment are made. A minute sample of the ash is placed on the flattened hot junction of a platinum/platinum-rhodium thermo-element which is gradually heated by an arc to the melting temperature of the ash. The melting is observed under a microscope. Experimental results are given. EF (2.07)

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ABSTRACTS

(Continued from Page 20)

On Adiabatic Calorimetry at Elevated Temperatures. (Über adiabatische Calorimetrie bei höheren Temperaturen.) W. KANGRO & R. GRAU. *Zeitschrift für physikalische Chemie, Bodenstein Festband*, 1931, pages 85-92.

An adiabatically operating calorimeter equipment is described and its applicability proven. It comprises a silver block wound by a heating coil which carries a silver thermostat; 2 Pt-resistance thermometers; a mirror galvanometer; a selenium cell. EF (2.07)

The Control of Waste Heat in Kilns. (Ueber die Konstrolle der Ofenabhitze.) G. CAESAR. *Tonindustrie Zeitung*, Vol. 55, April 13, 1931, pages 434-436.

Importance of measurement is stressed; performance is given; indicating and recording instruments are discussed. Diagrams of actual measurements are included. EF (2.07)

Why Is Absolute Zero Unattainable? (Warum ist der absolute Nullpunkt unerreichbar?) H. SCHMOLKE. *Zeitschrift fuer die gesamte Kaelte-Industrie*, Vol. 38, June 1931, pages 86-88.

Author shows it is thermodynamically impossible. EF (2.07)

A New Oil Tester. (Ein neuer Oelpruefapparat.) F. CROTOGINO. *Petroleum*, Vol. 24, May 13, 1931, pages 4-5.

Describes new oil testing equipment of the Allgemeine Elektrizitaets Gesellschaft for measuring water content and insulation value. EF (2.10)

Various Kinds of Oil Testers. (Verschiedene Apparate zur praktischen Wertbestimmung von Oelen.) *Petroleum*, Vol. 24, May 13, 1931, pages 6-7.

Illustrated descriptions of equipment of the J. Woudhuysen Co., Brussels. EF (2.10)

The Conductivity of Pure Liquids. (Uber die Leitfähigkeit von reinen Flüssigkeiten.) A. NIKURADSE. *Zeitschrift fuer physikalische Chemie*, Section A, Vol. 155, June 1931, pages 59-64.

The experiments aim at the purification of liquid media to the highest possible degree. Hexane was employed because of its utilization for investigations on the conductivity phenomena in dielectric liquids at high field densities and on the phenomena met with at the contact between metal and pure dielectric liquids (constant voltage). EF (2.10)

Determination of the Viscosity of Oil In the Tausz Ball Drop Viscosimeter. (Bestimmung der Zaehigkeit von Oelen im Tauszschen Zugelfallviskosimeter.) F. GEIGER. *Petroleum*, Vol. 27, March 18, 1931, pages 209-214.

Author concludes: It is established by a great number of experiments with the Tausz Ball Drop Viscosimeter that by simple multiplication of the falling times of the ball with a certain coefficient, data are obtained which closely correspond to the absolute degrees of viscosity as determined by the Oswald Viscosimeter. The limitations of this relationship are set forth. EF (2.10)

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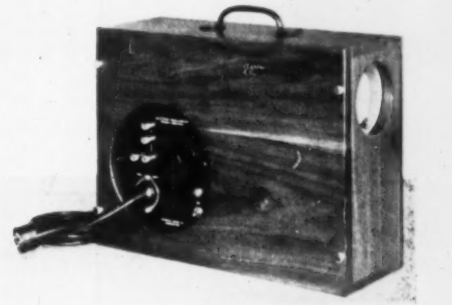

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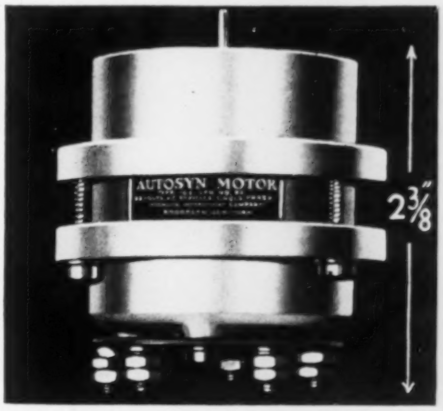

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